Annual Equipment Issue

ADVANCE COPY

SCIENCE

21 October 1955

Volume 122, Number 3173

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

file *any* or *all* of these

1" MICROSLIDES

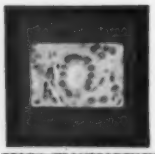
or

2" MICROSLIDES

or

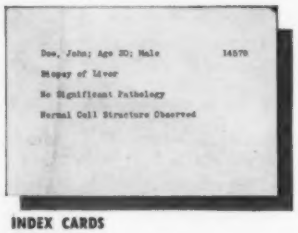
3¼ X 4¼ LANTERN SLIDES

or



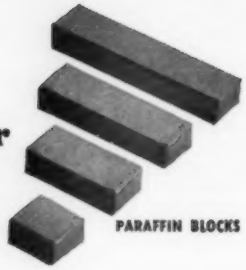
COLOR TRANSPARENCIES

or



INDEX CARDS

or



PARAFFIN BLOCKS

in easy-to-file,[1] easy-to-find,[2] space-sparing,[3] safe organization and, above all, economically[4] in a

TECHNICON *Lab-aid*

laboratory filing cabinet

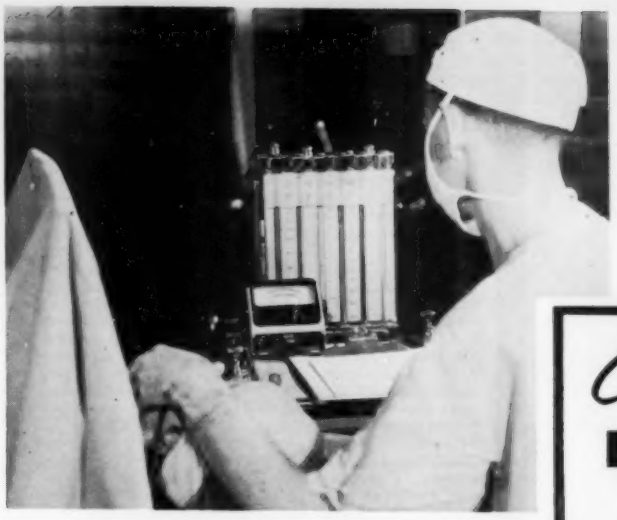
1. patented "Lab-aid" spring separators let you riffle slides like book pages • the one you're seeking pops right into sight.
2. a stack of "Lab-aid" cabinets needs only 19" x 19" floor space.
3. steel fireproof construction and true-tracking design brings drawers straight out • slides don't crush against frame. Nor can drawers pull out accidently and crash on floor.
4. a single 14 drawer section will accommodate up to 6500 microslides.

Technicon LAB-AID is more than a simple cabinet . . . it is an integrated filing system which brings order and efficiency to every laboratory filing need. Write today for detailed information.

The Technicon® Company
Chauncey, New York

"Lab-aid" Cabinets are manufactured by our French Corporation
COMPAGNIE TECHNICON • 7 rue Georges Ville • Paris

SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Entered at the Lancaster, Pa., Post Office as second class matter under the act of 3 March 1879. Annual subscriptions: $7.50; foreign postage, $1; Canadian postage, 50¢.



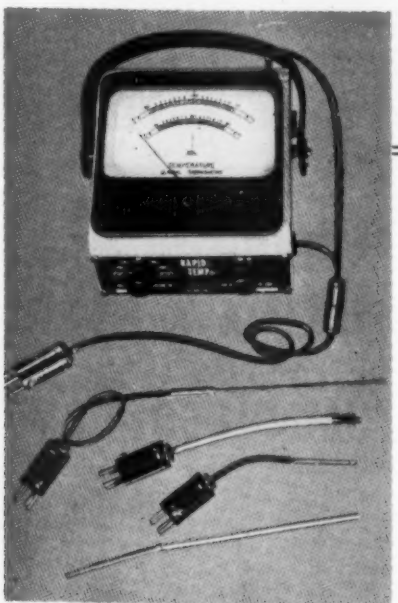
The Electronic Rapid-Temp Thermometer is a valuable instrument in measuring the temperature of patients while under operation. A constant indicating temperature can be read either for hyperthermia or hypothermia. The Rapid-Temp Thermometer is being used at present in many hospitals.

Can Also Be Used for Remote or CONTINUOUS OBSERVATIONS! ACCURACY ± 0.1° F. OVER THE CLINICAL RANGE!

Clinical Temperatures
IN SECONDS
instead of Minutes!

RAPID-TEMP, THE NEW ELECTRONIC CLINICAL THERMOMETER

Gives Accurate, Practically-Instantaneous Clinical Temperatures by Oral, Rectal or Axillary Methods!



RAPID-TEMP is a new and revolutionary type of clinical thermometer which has the speed and accuracy of modern-day electronics. This simple instrument utilizes a thermal sensing element and operates on the output of a flashlight battery. Except for the meter there are no moving parts and no electronic tubes to burn out and the battery has a useful life of approximately 1 year.

Cat. No. 96894 — RAPID-TEMP, Range 70° to 110° F., complete with one all-purpose probe...ea. $110.00

Cat. No. 96895 — RAPID-TEMP, Range 90° to 110° F., complete with one all-purpose probe....ea. $95.00

Cat. No. 96893 — Extension cord, 10 ft. Complete with plugs.....ea. $4.50

PROBES
Immediate Delivery

Cat. No. 96896—All purpose, stainless steel, oral or rectal, 18" lead from plug, 4½" long, 0.120" diam., time constant in oil, 5 seconds.....ea. $21.00

Cat. No. 96897—Super-speed, glass, oral, 18" lead from plug, 2" long, 0.1" diam., time constant in oil, 1 second.....ea. $10.00

PROBES—Special Order (30-45 Days' Delivery)

Cat. No. 96898—Fast, oral, stainless steel, 18" lead from plug, 4½" long, 0.083" diam., time constant in oil, 2½ seconds.....ea. $21.00

Cat. No. 96899—Tissue temperature, hypodermic needle, #18 gauge, 2" long, 18" lead from plug, time constant in oil, 2½" seconds..ea. $36.00

Cat. No. 96900—Skin temperature, plastic, 18" lead from plug, 4½" long, 0.120" diam., time constant in oil, 1 second.....ea. $25.00

RAPID-TEMP enables the user to take accurate clinical temperatures by the oral, rectal or axillary methods in a matter of seconds instead of minutes, minimizing discomfort to the patient. RAPID-TEMP's action is, for all practical purposes, instantaneous, since a reliable and accurate temperature is obtained in 5 seconds. It completely eliminates the long waiting period in obtaining body temperatures. *Accuracy is plus or minus 0.1° F. over the clinical range.* Ruggedly constructed RAPID-TEMP consists of two main components . . . a THERMA PROBE (which encases the thermal sensing element) and an INDICATOR. Probes are interchangeable and replaceable and can be sterilized in boiling water or cleaned with alcohol. No "shaking-down" is required. The easily and accurately-read INDICATOR UNIT consists of a special 4" scale suppressed indicating meter, selector switch, battery adjustment control and 1.5 w flashlight battery.

APPLICATIONS

HOSPITALS—Huge savings of time in daily routines . . . and a "must" for continuous observations in the operating room.

DOCTORS—An asset in every busy office. Pediatricians will find it a great help in taking temperatures of infants.

RESEARCH LABORATORIES—Animal temperatures are greatly facilitated by RAPID-TEMP's rapidity. Eliminates the difficulty of holding animals quiet for minutes at a time.

ARMED FORCES AND INSTITUTIONS—A tremendous time-saver for mass physicals and periodic examinations.

STANDARD SCIENTIFIC SUPPLY CORP.
34 West 4th Street • New York 12, N. Y.
LABORATORY APPARATUS — REAGENTS AND CHEMICALS

MICROPRINT CARDS

New Kodagraph Microprint Reader makes them a pleasure to read

The microprint idea can reduce the largest library to a small set of cards. Sixty conventional pages can go on a 3 x 5-inch card, with an abstract and filing data in ordinary-size type on the other side.

The Kodagraph Microprint Reader lets you read in complete comfort. The screen is green and tilted 11° because that's the combination that seems to be easiest on the eyes. It's bright enough to use in ordinary room light. Several people can read at a time.

You feed microprint cards into a Kodagraph Microprint Reader like paper into a typewriter —any size up to 8½ x 14 inches.

Many publishers offer microprint card editions. Many are also prepared to make microprint cards for you from your own literature and reports.

To get started on a microprint system that can help solve the problems of debulking, speedy dissemination, and storage of literature and private internal data, mail the coupon below.

EASTMAN KODAK COMPANY '65

Business Photo Methods Division, Rochester 4, N. Y.

Please send me the information checked:

- ☐ Where I can see a Kodagraph Microprint Reader.
- ☐ Folder on the Reader and sample microprint card.
- ☐ List of publishers of microprint cards and manufacturers of microprint cards to order.

NAME_____

ADDRESS_____

Kodak TRADE-MARK

Now available . . .

Adenosine Triphosphate (ATP); Amygdalin; Amylase; Animal Lecithin; Ascorbic Acid Oxidase; Bacitracin; BAL; Biotin, cryst.; Caffeic Acid; Carotene, cryst.; Catalase; Cellulase; Chlorogenic Acid; Chorionic Gonadotropin; Circulatory Hormone; Colchicine; Cytidylic Acid; Cytochrome C; Dehydroascorbic Acid; Diacetoneamine; Dihydroxyacetone; Dihydroxyphenylalanine (DOPA); Dipyridyl; Edestin; Emulsin; Erythritol; N-Ethylpiperidine; Fibroin; Folic Acid; Galacturonic Acid; Gentistic Acid; Girard Reagents P and T; Gliadin; Glucose Pentaacetate; Glucuronic Acid; Glyceraldehyde; Glyceric Acid; Heparin; Hordenine; Hyaluronidase; Hydrindene; 2-Hydroxyadipaldehyde; Humulon; Indan; Isoascorbic Acid; Isopropylarterenol; Kojic Acid; Kynurenic Acid; Lanthionine; Lipase; Lysozyme; Lyxose; Malononitrile; Maltase; Melezitose; Mesobilirubinogen; Muscle Adenylic Acid; p-Nitrophenylphosphate; Nucleoprotein; Orcinol; Pancreatin; Pantothenyl Alcohol; Penicillinase; Peroxidase; Phenazine; Phenylpyruvic Acid; Phloridzin; Phosphorylase; Piperin; Porphyrindine; Protamines; Protoporphyrin; Pyridoxal; Pyridoxamine; Pyrocatechuic Acid; Pyruvic Aldehyde; Ribonuclease; Saccharic Acid; Salmine; Serine Phosphoric Acid; Spermidine; Spermine; Thioacetic Acid; Thiocytosine; Thyroxine; Trigonelline; Triphenyltetrazolium Chloride; Tripyridyl; Trypsinogen; Tyrosinase; Tyrothricin; Urease; Uricase; Uridine; Vitellin; Xanthosine.

Ask us for others!

DELTA CHEMICAL WORKS, INC.

23 West 60th St. New York 23, N.Y.
Telephone PLaza 7-6317

romicron

EXPOSURE METER FOR PHOTOMICROGRAPHY

- self contained, no external wires
- instantaneous readings
- removal from microscope unnecessary
- adaptable to any standard microscope
- readings are easily taken by moving a lever

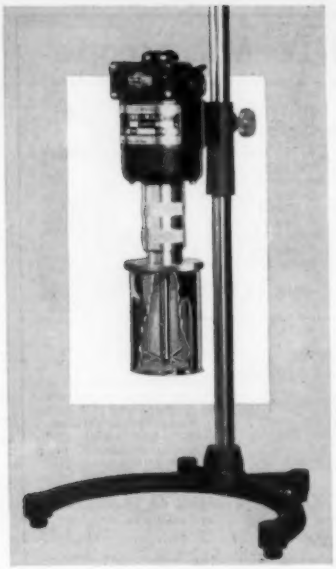
Ideal for:
Bellows Cameras
Attachment Cameras
Beamsplitters and
Motion Picture Units

Write for pamphlet S-24

PAUL ROSENTHAL

505 Fifth Avenue New York 17, N. Y.

Microscopes & Scientific Apparatus



SERVALL

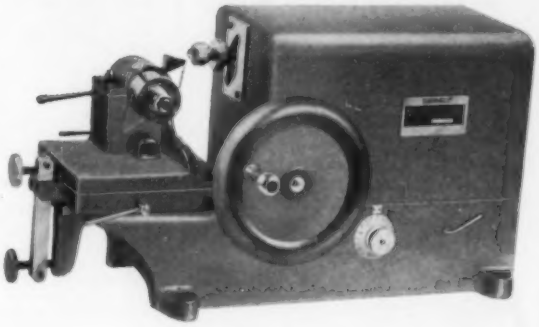
QUALITY, DEPENDABILITY, PERFORMANCE

Backed by 25 years of pioneering and engineering "know-how"

left:

OMNI-MIXER: High-speed, 200-ml laboratory mixer for rapid, safe homogenizing, mixing, disintegrating. Leak-proof construction • shaped, stainless-steel mixing chambers • accommodates mason jars. Rapidly disassembled for sterilization.

Write for Bulletin SC-106.



left:

SERVALL SS-1 SUPERSPEED ANGLE CENTRIFUGE: 15,500-rpm—31,000 x G—400-ml. "The workhorse of the modern laboratory." Versatile rotor • dynamic-balancing assembly • compact construction. Many features originated and developed by SERVALL now used as trade standards. SERVALL SS-1A, same as SS-1 but with heavy duty water-cooled bearing assembly.

Write for Bulletin SC-101.

above:

MICROTOME: 1/40 to 1/2 micron. Ultra-thin sectioning for electron microscopy. Mechanical advancement • versatile adjustable knife-holder • tissue thickness control dial • collet-type chuck.

Write for Bulletin SC-105.

below:

SERVALL M, SP & SP/X ANGLE CENTRIFUGES: 5,000-rpm—3,500 x G.

Type M accommodates twenty-seven 15-ml tubes

Type SP will hold six 75-ml tubes (plain)

Type SP/X can spin ten 50-ml tubes and five 15-ml tubes in one operation. Also, other types of angle centrifuges available.

Write for Bulletin SC-101.

right:

SERVALL REFRIGERATED ANGLE CENTRIFUGE: 15,500-rpm—31,000 x G—2,000-ml Direct drive on central spindle—no special, awkward attachments required. Many different heads may be spun in this functionally versatile machine . . . and each head may be made more versatile by use of adapters. Temperatures well below 0° C. may be established and held. Stainless-steel evaporator • angle principle • self-centering assembly • electronic tachometer • temperature holding control • unitized construction • true hermetic high capacity refrigeration unit—ALL ORIGINATED BY SERVALL.

Write for Bulletin SC-101R.

Write for Literature

Ivan Sorvall, Inc.

P. O. BOX 230, NORWALK, CONNECTICUT

GUARANTEED

CONCLUSION:

"Meets the U. S. P. 14 requirements for distilled water, sterile distilled water and water for injection"

**INDEPENDENT LABORATORY*

July 21, 1955

Precision Scientific Company — No. 44425
3737 West Cortland Street — U.S.P. - 14
Chicago 47, Illinois

Gentlemen:

REPORT

SUBJECT: Examination of water produced in our laboratories by distilling Chicago city water with your Precision "Streamliner" Laboratory Water Still.

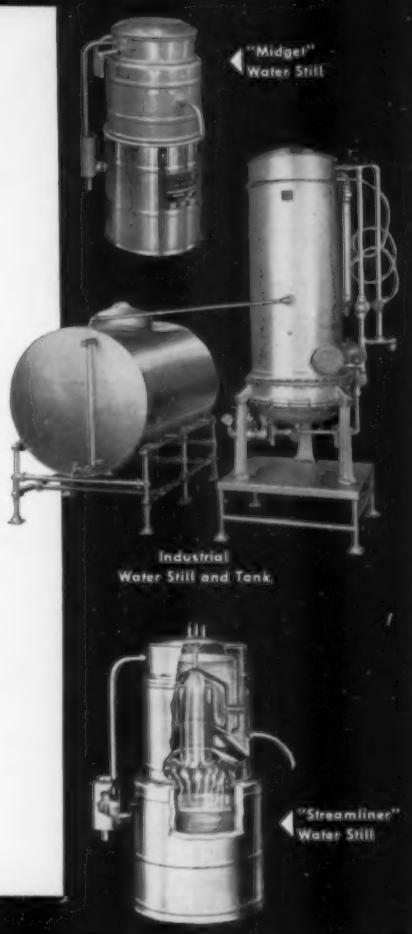
Chemical Examination	Parts per million
Total solids	1.00
Silica - SiO_2	0.066
Iron and alumina - Fe_2O_3 Al_2O_3	Trace
Calcium - Ca	0.07
Magnesium - Mg	No weighable trace
Sodium and Potassium	Less than 0.10
Sulfate	No weighable trace
Chloride	Less than 0.10
Alkalinity as carbonate	Less than 0.10

This water passes the following U. S. P. tests listed under Distilled Water and therefore meets this specification in its entirety:

Appearance	Ammonia
Color	Calcium
Odor	Carbon Dioxide
Taste	Heavy Metals
Reaction	Total solids (see also above)
Chloride	Pyrogen-free
Sulfate	

Conductivity Test: 3.5 Micromhos

**NAME SUPPLIED UPON REQUEST*



SINGLE DISTILLATION PRODUCES WATER FIT FOR INJECTION

This independent laboratory report on the distillate of a Precision "Streamliner" Water Still clearly shows the results to be expected from the entire line of Precision Water Stills.

PERFORMANCE OVER THE YEARS

Experience *over the years* has proved that water stills by Precision produce a purer distillate in more volume with less attention at lower cost. In operation, they meet *all* U.S.P. standards, produce pyrogen-free water and reduce total solids to 1 part per million!

FROM A TRICKLE TO A TORRENT

All Precision models are *hard water* stills. Your capacity requirements from 100 to ½ (gallons per hour) CAN BE DELIVERED FROM STOCK IN MOST MODELS.

A new brochure covering all models of Precision Water Stills, Storage Tanks and Accessories is available. Why not write for it today?

Precision Scientific Company

3739 WEST CORTLAND STREET • CHICAGO 47

21 October 1955, Volume 122, Number 3173

SCIENCE

SCIENCE, founded in 1880, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879.

SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

All correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors.

Change of address: The notification should reach us 4 weeks in advance. If possible, please furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $7.50; foreign postage, $1; Canadian postage, 50¢. Single copies, 25¢. Special rates to members of the AAAS. Cable address: Advancesci, Washington.

The AAAS also publishes THE SCIENTIFIC MONTHLY.

More Power to Research

Observation, measurement, and control comprise the cornerstone of experimental science. Without them, even the theoreticians would be operating in a partial vacuum. Instruments and apparatus, the indispensable tools of the research scientist, constitute the means for carrying out these techniques. Without them there could be no laboratory.

The speed with which science has been moving during the past decade is clearly associated with the science of instrumentology and the art of instrumentation. Twenty years ago a physicist or chemist, competent in his science, was expert in experimental methods required not only in his own research but also, broadly, in the whole field of his science. Today he is even more expert, perhaps, in the experimental means and methods of his own restricted area; but the tremendous development of equipment, which has kept pace with—or has, in fact, paced—the advance of science, has left him far in the rear. The research worker in the life sciences, unless he has a flair for experimental procedures, is even less favorably situated.

No argument is needed on the point that continuing progress in all the sciences is profoundly dependent on physical tools, devices, and equipment; on the methods of their use; and on the procedures by which quantitative observations are processed for the testing of theory or hypothesis. Nor can it be doubted that the basic knowledge and skillful use of instruments and apparatus now constitute in themselves an area of specialization.

Some scientists hold the opinion that such activity renders its practitioner a second-class citizen in the science community. In this puristic view such scholarly work is "applied" science, which is at least one step below the level of "pure" science. Against this, the position is tenable that applications of science to the pursuit of truth are as important to the advancement of knowledge as is the purely intellectual effort. Both are indispensable, and, indeed, it has never been otherwise.

A conclusion to be reached in considering the future of science is that specialization has long been the route by which knowledge advances; and that specialization in the field of observation, measurement, and control is an inevitable trail that must be followed toward greater productivity in research. A specialist in the research problem of making science serve science more effectively has an important role as guide if not leader in the expedition.

Under a grant from the National Institutes of Health, the National Research Council is carrying on a study to determine in what manner the theory and application of measurement and control, with all their implications, may best serve research in the biological and medical sciences. The findings should have potential value to all research scientists, especially if the way is pointed for them to conserve their time and effort for their own specializations and to depend for aid and advice in the other specialized problems on experts in observation, measurement, and control.

PAUL E. KLOPSTEG

21 October 1955, Volume 122, Number 3173 SCIENCE

Experiments at Very Low Pressures

D. Alpert

In the years since World War II, developments in experimental techniques have taken place that have made it possible to achieve and to measure pressures three to four orders of magnitude lower than those previously possible. Based in part on the work I have briefly described as well as on the important pioneering work of W. B. Nottingham, P. A. Anderson, L. Apker, and others, a new technology has been evolved for the region of pressures below 10^{-8} mm-Hg, a range which I think it is reasonable to call ultrahigh vacuum. The extension of the range of pressures attainable at room temperatures was motivated largely out of requirements in the fields of (i) physical electronics, in which it is now possible to study reactions with atomically clean surfaces, and (ii) gaseous electronics, in which it is the partial pressure of impurities rather than the total pressure that must be kept in the ultrahigh-vacuum range. M. A. Biondi (*1*) of Westinghouse Research Laboratories has shown that it is possible to prepare gases with an impurity content of less than one part in 10^9.

In this article I have reviewed very briefly some aspects of ultrahigh vacuum technology that have grown up as a result of continued interaction among various workers at our laboratories. I have been very brief because much of this material has been described in publications during the course of the past 3 years (*2*, *3*). Thereafter I have described, at least by title, a number of studies that have been either made possible or tremendously improved by the advent of these very low pressures.

The author is manager of the physics department of the Westinghouse Research Laboratories, East Pittsburgh, Pa. This article is based on a paper that was first presented at the Berkeley meeting of the AAAS, 30 Dec. 1954, when Dr. Alpert received the Newcomb Cleveland prize.

Basic Developments and Techniques

Some of the basic developments underlying the new technology are (i) an ionization gage to measure pressures down to 10^{-11} mm-Hg; (ii) an all-metal vacuum valve for manipulative and gas-handling systems; (iii) "ion pumping" to evacuate systems to pressures below 10^{-8} mm-Hg; (iv) new approach to design and engineering of vacuum systems; and (v) demountable systems. In a paper by R. T. Bayard and D. Alpert (*4*), it was shown that the standard ionization gage has a lower pressure limit of about 10^{-8} mm-Hg. The limitation is caused by a current to the ion collector that is produced by soft x-rays formed when the ionizing electrons strike the grid. The x-rays in turn release photoelectrons from the ion collector that produce a current completely independent of the pressure but of the same sign as ions arriving at the collector. By greatly reducing the solid angle available to x-rays, we showed that it was possible to lower the limit of measurable pressures by a factor of approximately 1000. A second development was the all-metal vacuum valve (*5*) capable of high-temperature bakeout. Such valves make it possible to seal off one part of a system from another, or to transfer gases with less than one one-thousandth of the contamination introduced by standard grease stopcocks. Third, we showed that it was possible to use the ionization gage as an ion pump to evacuate to very low pressures. Empirically, one finds that positive ions formed in the grid volume of a gage are, more or less, permanently removed from the volume after they have struck negatively charged surfaces. Fourth, we have adopted an entirely new approach to the design of vacuum systems for experiments in physical and gaseous electronics. Principles of design and engineering have been introduced into a field that has included much conjecture and has been more of an art than a science. Finally, it has been shown that it is possible to design ultrahigh-vacuum systems containing demountable joints. I have not listed some other very useful developments such as a bakable absolute manometer for the measurement of higher pressures and special vapor traps (*6*) with unusual characteristics that I have described in a subsequent paragraph.

Using these means, it has been possible to achieve working pressures as low as 10^{-10} mm-Hg in a routine and straightforward way with no refrigerants or chemical getters of any kind. We have some 17 to 20 systems of this type in use in our laboratories at the present time, and many of us feel that it is easier to obtain pressures of 1 or 2×10^{-10} mm-Hg in such systems than it used to be to produce pressures hundreds of times greater with conventional means. A crucial requirement for any such system is that the entire system should be capable of high-temperature bakeout. Figure 1 shows a system in which the vacuum valves, ionization gages, and gas source are ready for assembly on a series of module units, each 16 inches square, which also form the bases for our standard-sized furnaces. To increase the size or complexity of our systems, we simply bolt down another module and attach the additional vacuum system with a simple vertical seal. Figure 2 shows our new standard furnaces in place. Each unit covers a single module and with this design we can vary the size of the system in either the horizontal or vertical direction. As previously indicated, we have found it possible to make demountable ultrahigh vacuum joints capable of repeated bakeout using gold gaskets squeezed flat between stainless steel or Monel flanges (*7*). Figure 3 shows a steel vacuum tank (10-liter volume) assembled with four such demountable joints for use in studies of breakdown at atmospheric pressures (*8*). I should like to call attention to two features of the system shown

in Fig. 3: (i) A vacuum valve is very often incorporated in our systems to isolate at will the system from the oil diffusion pump. In the region of pressure of 10^{-7} mm-Hg, such pumps become a source rather than a sink for contamination; by isolating the pumps completely, it is possible to attain ultrahigh vacuum through the use of ion pumping alone. (ii) The pumping speed of the system shown is extremely low; it is only of the order of 0.1 liter per second, although the working pressure of the system is 10^{-9} mm-Hg. Ordinary vacuum techniques would call for pumps hundreds of times greater in size and would at best attain ultimate pressures hundreds of times greater.

Another type of demountable joint, this one developed by Pattee (*9*) at Stanford University, is shown in Fig. 4. By utilization of a replaceable copper gasket, two portions of a system may be joined or electrodes may be inserted into a system by clamping the gasket between stainless steel flanges. The flanges have knife-edged ridges, as shown; when clamped, they form a vacuum-tight and flexible seal.

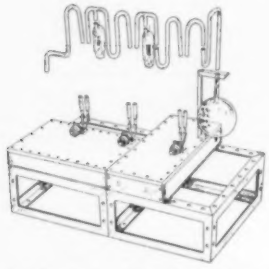


Fig. 1. Vacuum valves, ionization gages, and gas source ready for assembly on a series of module units.

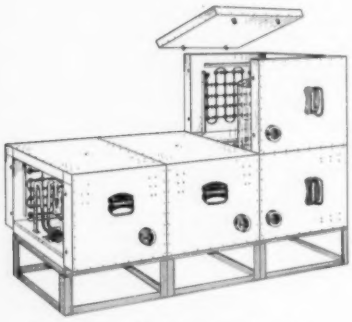


Fig. 2. Standard furnaces in place.

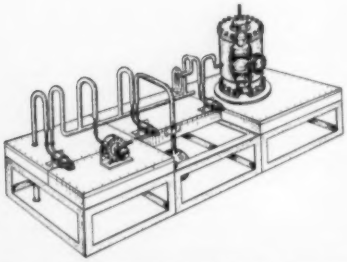


Fig. 3. Demountable breakdown chamber for very pure gases.

With these techniques, it has been possible to carry out experiments in a number of areas of physics that until recently have been both literally and figuratively "dirty" physics. One whole field of activity has grown directly from the ingenious field-emission microscope invented by Erwin Müller in 1937 (*10*). The device maps the cold electron emission pattern from a very fine metallic point with a tip of the order of 10^{-4} to 10^{-5} centimeter in diameter. By accelerating the electrons to a large fluorescent screen, one obtains a linear magnification as high as 1 million. Pattee and others have used the emission from such a tip in very interesting applications involving the production of very small x-ray spots. A large number of other workers, including W. P. Dyke, J. Becker, and R. Gomer, have used this idea in conjunction with the newly available ultrahigh-vacuum techniques to open up investigations in the fields of surface migration, chemisorption, field emission, and in various studies of gas and surface reactions on solids. It is well known that the characteristic field emission pattern in a Müller tube is remarkably altered by extremely small quantities of gas. And how much is extremely small? Well, the experts are still arguing (rather inconclusively) about whether it is possible to see a single adsorbed molecule. And when you consider that at 10^{-6} mm-Hg a whole monolayer of adsorbable gas is deposited in 1 second, you realize why it is essential to get pressures down to 10^{-10} mm-Hg and even lower if possible.

Another field that requires very low pressures and in which great strides have been made in recent years involves the interaction with solid surfaces of atomic particles such as ions, metastables, and light quanta. An example is the work of H. Hagstrum (*11*) at Bell Telephone Laboratories, who has measured the coefficient, γ_i, for the ejection of electrons from metals by incident positive ions. He has shown that most of the results of the past two or three decades in this field are subject to serious question because γ_i is very sensitive to the condition of the metal surface. In the case of tungsten, it has been found that even when the metal is baked out at 1000°C, it acts as if a layer of oxygen or of nitrogen is still attached to the surface. The effect disappears only when the metal is baked out at even higher temperatures. Such fields as gaseous electronics, or analytic mass spectrometry are ones in which ultrahigh vacuum techniques are uniquely applicable.

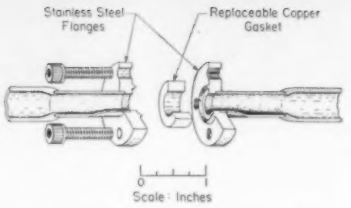


Fig. 4. Pattee demountable vacuum joint.

Limitations to Production

A number of interesting researches have grown out of our attempts to understand the limitations on the production of very low pressures. For example, although the x-ray limit of our ionization gage is approximately 10^{-11} mm-Hg, we had until recently never measured pressures in a sealed-off portion of a system below 3 to 4×10^{-11} mm-Hg even with the ionization gage running and therefore pumping continuously. We examined all sorts of possibilities for the causes of this limitation. First, we showed that the gage was linear over its usable range and calibrated it absolutely. Next, we measured the equivalent pressure reading owing to tungsten atoms that originate at the hot filament of the ionization gage and pass through the grid on the way to the glass envelope. In the process, we demonstrated a simple and straightforward way to get an approximate value for the vapor pressure and an accurate value for the heat of vaporization of refractory metals. The experiment showed that the equivalent pressure due to tungsten atoms evaporating from the

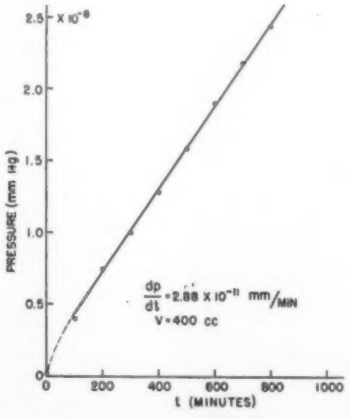


Fig. 5. Rate of rise of pressure in a typical vacuum system.

filament of the ionization gage was approximately 10^{-12} mm-Hg. But these results did not give insight into the reasons for the residual pressure.

Information concerning the source of residual gas in sealed-off systems was first obtained from measurements of the rate of rise of pressure in such systems. If in a sealed-off system all pumping action is eliminated, we find that no matter how carefully the vacuum system has been prepared, we observe an easily measured residual rate of rise as shown in Fig. 5. This rate of rise depends, of course, on the volume and surface area of the vacuum systems; for a typical system it was of the order of 2 or 3×10^{-11} mm-Hg per minute. This is not a very large leak; it corresponds to a rate of rise of 1 micron per century, but it could very readily be measured and was found to continue linearly for at least 75 days. Even after many days of such a rise, however, there was no indication of an adsorbable gas within the system. From these observations, we inferred that an inert gas, probably a noble gas, came from outside the system, possibly diffusing through the glass walls of the enclosure. From rather sketchy data, we found that the rate of rise was not inconsistent with the hypothesis that the gas was helium, which is present in the atmosphere to only a few parts in a million. But since there was a large discrepancy among various measurements of the permeation rate for helium in Pyrex, it was not possible to rule out other sources.

We therefore proposed a simple experiment to determine the answers to the question: Does the gas come from outside the system and, if so, what is the mechanism involved? The experiment consisted of enclosing a carefully sealed-off ionization gage within another vacuum system. Then, if at time $t = 0$ the outer pressure were reduced to zero, the rate of rise in the inner system should vanish. The data of Fig. 6 show that it did vanish, but that it took almost 60 days to do so. This strongly indicated a diffusion process, and a thoroughgoing consideration of the data showed that we could get not only the permeation rate k, but also the diffusion coefficient D and the solubility S. The permeation rate k is, of course, equal to the product of D and S. From the curve in Fig. 6, we obtained values for D and S, as well as k, and would have liked to compare them with existing data. We found that no measurement of D had ever been made and that S had been measured only once, at a temperature above 500°C. We then proposed a new experiment to measure k, D, and S for helium in Pyrex and to check the nonstationary diffusion equation for this process (*12*). The experiment is shown schematically in Fig. 7. Two ultrahigh vacuum systems were

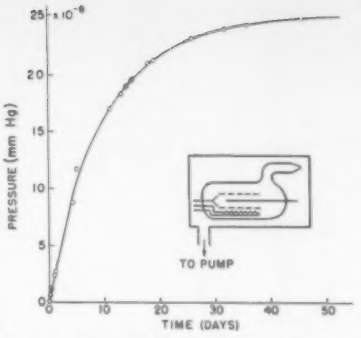


Fig. 6. Sealed-off ion gage in a vacuum.

separated by a Pyrex diaphragm of thickness d and area a. At time $t = 0$, helium at a known pressure, P_A, was introduced on one side of the diaphragm and the pressure in the receiving volume, P_R, was measured as a function of time. I do not have space to describe the experiment in detail, but I show in Fig. 7 the usual diffusion equations and an approximation that is excellent at small times. By plotting the data in the form suggested by this equation, we were able to get from the slope of a semilogarithmic plot the values of the diffusion coefficient D, and from the intercept a value for the solubility S of helium in Pyrex glass. We checked the values of D and S with those for the unknown gas in the glass walls of our vacuum systems and thus obtained a conclusive confirmation of the helium hypothesis. We verified the diffusion mechanism for this process and obtained very interesting data on the variation of the diffusion constants with temperature.

To return to my original question, we have by this and other methods identified the incoming gas as helium. The question that remains is this: Does this process account for the entire residual pressure of 3 to 4×10^{-11} mm-Hg found in a typical system? From the ordinary equation for the pumping speed of a system, the rate of change of pressure is given by

$$\frac{dp}{dt} = -\frac{S}{V}p + r, \qquad (1)$$

where S is the pumping speed of the system, V is the volume of the system, and r is the total rate of pressure rise in the system. The ultimate equilibrium pressure is obtained when the rate of change of pressure vanishes and the equilibrium pressure p_e, is given by

$$p_e = rV/S = r\tau, \qquad (2)$$

where $\tau = V/S$ is the characteristic time required to pump the system down to $1/e$ of its original pressure. Now the residual rate of rise r, has been measured to be about 3×10^{-11} millimeters per minute; τ is easily evaluated and for a typical system has been measured to be approximately 1 minute. Thus the expected residual pressure is equal to the product of r and τ and is equal to 3×10^{-11} mm-Hg. The entire residual pressure can be accounted for as the result of the diffusion of pure helium into the system. Under good conditions, we have indications that the nonhelium contamination is less than 10^{-13} mm-Hg.

Many people would be happy with this kind of vacuum; but in a number of experiments even this value of equilibrium pressure, as well as corresponding rate of rise, is altogether too high. In the diffusion experiment, in experiments on the adsorption of gases on surfaces, and in a number of other researches, one would like to reduce the ultimate pressure to even lower values. From Eq. 2, it is clear that one way to reduce p_e is to reduce or eliminate r. Varnerin and White (*13*) have done this by enclosing one vacuum system completely within another and sealing both to a kovar tubulation as shown in Fig. 8. In this way, pressures have been obtained that have been estimated to be below 10^{-11} mm-Hg. Under such conditions, we can no longer measure pressures and we need a new type of gage.

Another way to reduce the ultimate pressure would be to increase the pumping speed of the system and thus to reduce τ. We have known for years that at pressures below 10^{-7} mm-Hg an oil diffusion pump constitutes a source of contaminating vapors. On the other hand, we have also known that oil diffusion pumps retain their pumping efficiency at pressures far below 10^{-7} mm-Hg despite the manufacturers' literature, which usually indicates that the speed of the

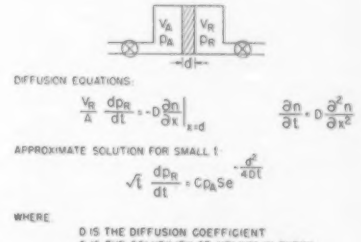


Fig. 7. Schematic diagram of diffusion experiment.

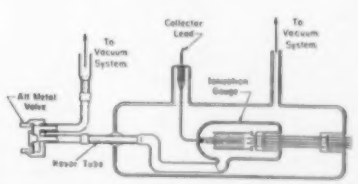


Fig. 8. Enclosure of one vacuum system within another.

pump goes to zero in this range. We felt that if we could design a trap that would prevent the backstreaming of oil vapor but not restrict the pumping action of the pump, we might be able to use the increased speed of the pumps to reduce our ultimate pressures. The trap used has been described in the literature (*6*) and is shown at *a* in Fig. 9. It consists of a standard reentrant glass trap into which corrugated copper has been inserted so that the trap contains a large number of fine copper straws. This trap design was originally proposed to solve the usual problem encountered with a refrigerated reentrant trap, that is, as the liquid refrigerant evaporates, the cold level drops and the gas that had previously been adsorbed is reevaporated into the system. In this design, it was intended to utilize the high thermal conductivity of the metallic insert so that the entire trap surface remained cold despite large fluctuations in the liquid level. The trap also affords an extremely high ratio of length to diameter without greatly sacrificing the speed of the system. It worked extremely well and eliminated the effect of variation of the liquid level. We used these traps for some time before we found that the trap worked very efficiently even when the liquid level dropped to zero. Since then, many of our traps have been designed for use without refrigeration, as shown in Fig. 9*c*, in a nonreentrant portion of the system. We then carried out an experiment in which such a trap was inserted between the system and a standard oil diffusion pump. After careful bakeout of the system, helium was introduced to a pressure of the order of 10^{-7} mm-Hg and the valve to the pumps was opened. The data of pressure versus time are shown in Fig. 10. They demonstrate that the oil diffusion pump continued to evacuate to a pressure below 10^{-10} mm-Hg with a constant pumping speed. The characteristic pumping time, τ, was measured to be 3.3 sec, equivalent to the computed conductance of the vacuum system. The corresponding pumping speed is 20 times that for an ionization gage. This higher speed did not result in even lower pressures because the rate of rise in this system was 1.2×10^{-9} mm-Hg, or 40 times the usual residual rate of rise. With smaller rates of rise, values of less than 10^{-11} mm-Hg have been obtained using standard oil diffusion pumps. To my knowledge, this is the first direct demonstration of the pumping efficiency of diffusion pumps in this range of pressures and constitutes another method for achieving pressures below our present range of measurement.

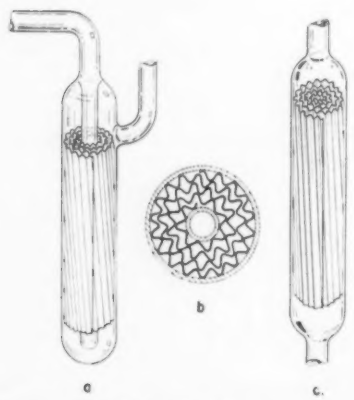


Fig. 9. Copper foil trap.

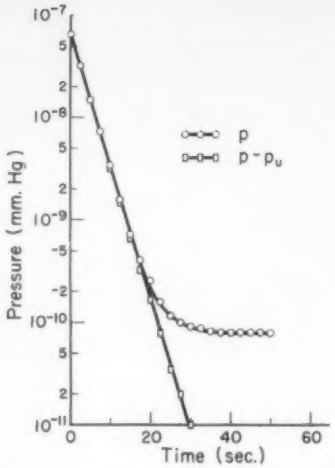


Fig. 10. Pump-down of helium by oil diffusion pumps.

Ion Pumping

I should now like to outline some of our most recent experiments designed to further understanding of the mechanism of ion pumping. I have previously described the studies directed toward obtaining an understanding of the rate of rise in our vacuum systems. We have felt that an understanding of the electrical pumping mechanisms might also be of great interest. Superficially, the ion pumping mechanism is very simple: ions formed in the volume of the ionization gage are driven into the negatively charged ion collector with an energy of 100 volts and are permanently removed from the volume (*14*). If every ion attached permanently to the surface, the resulting τ would be of the order of 1 minute, which is, in fact, the measured value of τ. But under some conditions, it has been found that for each ion that strikes the ion collector, two or even more atoms are removed. In fact, it is found that when a voltage is applied to the accelerating grid, atoms may be removed even when the ion collector potential is such as to repel ions. The answer to this question is relatively simple. Many ions are formed not only within the grid volume of the gage but also between the grid and the glass envelope of the gage. In this case, a little investigation shows that the glass walls may float at a negative potential so that the ions are driven largely into the glass envelope of the gage and, apparently, are permanently removed. But here again we are faced with a quandary because, if the gas is helium—and we obviously think it is—and if the ions are driven into the surface a few angstroms deep, we know from our recently attained knowledge of the diffusion coefficient that the helium atoms should diffuse out of the glass in a characteristic time of approximately 1 microsecond. That is, the gage should pump for only a few microseconds and then stop. As far as we have been able to determine, however, the gage pumps helium for an indefinite time. The answer to this problem was not readily forthcoming. Finally, L. J. Varnerin, one of my laboratory colleagues, demonstrated the answer in a very simple experiment (*15*) after he suddenly realized that the envelope of the gage was not glass at all, but consisted of a very fine layer of evaporated and sputtered metal transferred during the outgassing of the grid. Thus if his conjecture were true, there should be no pumping action with an absolutely clean ionization gage; if the glass walls were then covered with a deposit by outgassing of the grid, one might expect to obtain a pumping action. Figure 11 shows the results. Curve 1 was taken with a new gage direct from the production line. After the system had been prepared, the gage was turned on and pressure was measured as a function of time. After the first few minutes, it was found that the characteristic pumping time τ, was measured to be thousands of times greater than the normal value. After a slight outgassing, which presumably deposited a metallic film so thin that no measurable light absorption was present, curve 2 was

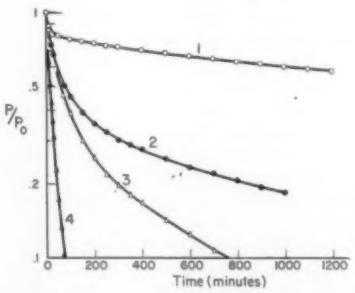


Fig. 11. Ionic pumping of helium by an ion gage after increasingly intense outgassing.

obtained with a very appreciable reduction in the time constant. After a little more outgassing and with a metallic film thickness estimated to be 10 angstroms thick, curve 3 resulted; and after a relatively heavy outgassing resulting in a film thickness of the order of 50 to 100 angstroms, the characteristic time had been reduced to its normal value of the order of a minute. This simple experiment clearly indicated that the helium ions are driven into the metallic deposit at the surface and that the pumping efficiency is strongly affected by the surface material. Very preliminary data would indicate that if the process of reemission of gas from the metallic surface could be described by a diffusion process, the diffusion coefficient would be approximately ten orders of magnitude less for helium in metals than for helium in Pyrex glass. Actually, Varnerin has shown in preliminary experiments that the reemission of such gas after it has been driven into the surface cannot be described by a simple diffusion process, so that we are not in a position to give diffusion constants for this material. Nevertheless, it is of interest to mention that we thought we were opening a new area in utilizing ultrahigh vacuums for the study of diffusion of helium in glass; we have now begun to investigate processes that are perhaps 10 orders of magnitude slower. Experiments are in progress that are intended to enable us to gain insight into the physical mechanisms by which excited or ionized gas may be attached to the surface of various types of solids.

Conclusion

With the description of these various fields of research, I have tried to outline a broad range of experiments that are greatly facilitated by the availability of a pressure range 3 or 4 orders of magnitude lower than that previously attainable. At the same time, I have indicated that there are a number of experiments for which even these new pressures are too high. I believe that we can produce significantly lower pressures than we can measure and that we need a pressure gage for the new range of pressure. I believe that the researches which are now being carried out at very low pressures will have interesting consequences for many areas of future scientific investigation.

References and Notes

1. M. A. Biondi, *Rev. Sci. Instr.* 22, 535 (1951).
2. D. Alpert, *J. Appl. Phys.* 24, 860 (1953).
3. D. Alpert and R. S. Buritz, *ibid.* 25, 202 (1954).
4. R. T. Bayard and D. Alpert, *Rev. Sci. Instr.* 21, 571 (1950).
5. D. Alpert, *ibid.* 22, 536 (1951). A recent modification of considerable interest has been described by Bills and Allen, *ibid.* 26, 654 (1955).
6. D. Alpert, *ibid.* 24, 1004 (1953).
7. M. A. Biondi, *Phys. Rev.* 94, 910 (1954).
8. M. Menes, unpublished.
9. H. Pattee, Jr., *Phys. Rev.* 98, A283 (1955).
10. E. Müller, *Z. Physik.* 106, 132 (1937).
11. H. Hagstrum, *Phys. Rev.* 91, 543 (1953); 96, 561 (1955).
12. W. A. Rogers, R. S. Buritz, D. Alpert, *J. Appl. Phys.* 25, 868 (1954).
13. L. J. Varnerin, Jr. and D. White, *ibid.* 25, 1207 (1954).
14. J. Koch, in Denmark, has shown that it is possible to separate isotopes of rare gases by driving them at energies of thousands of volts into separate metallic disks. The trapped gas may be retained in the metal for long periods of time.
15. L. J. Varnerin, Jr. and J. H. Carmichael, *J. Appl. Phys.* 26, 782 (1955).

Patent Work in a Small Company

Theodore C. Browne

It sometimes happens that a large industry has a gap in its technology. That industry may make a product that receives wide acceptance, but the public may be utterly unaware that any manufacturing difficulties exist; nevertheless, the manufacturers are continuously harassed by their efforts to skirt around a technological hiatus.

When an inventor outside the industry finds a way to plug the gap, founds a company, and plans to service the industry with the element that had previously been missing, the best laid plans for an orderly development of the new company may go awry. Research men necessarily become production engineers, treasurers, packaging engineers, traffic experts, customer service men, product improvers, capital raisers, and experienced salesmen simultaneously. Things happen so fast and customers' demands become so pressing that the truly creative minds in the organization have little time to work with patent counsel, to build an ordered plan of protection, or to secure sound foreign patents. Then, too, there is no time for these men to study the art, learn its direction, study newly developed materials, and be made aware of the trends that they must know.

So, I would say to a young man: "If you have a faith in the idea, an urge to help a business grow, and if you are well trained in patent soliciting and the techniques of research, even if the enterprise is tiny, join it, and found its patent department; the growth of a company you know you have helped to grow will be your reward."

I will assume that you have been a junior in a patent law office or an examiner in Washington. As soon as you become a member of the new organization, the environmental change will be nearly overwhelming. If you have been an examiner, you have always been met in patent matters by a *fait accompli*. The story came to you complete, and if you are like most examiners, you read the claims before you read the patent specification and therefore you knew how the detective story would come out. If you have been a junior in a law office, you have had the inventor sit at your elbow, explain his idea, show you photographs of his machine or samples of his product, and here also you were met by a completed technological accomplishment. True, you might have spent a day or two at your client's plant, studying the process or watching the operation of the machine. You might have dug into books to inform yourself on possible ranges of equivalents. You might have asked for further tests and more detailed information, but ultimately there came a time when you realized that neither your client nor you could afford to spend any more time on the problem and that you had to write the best specification possible from the information already at hand.

In the new organization, you will have no such advantages. Your associates will be out of the laboratory more frequently than they are in it. You will have to catch their ideas and suggestions as they drift

Mr. Browne is patent attorney of Dewey and Almy Chemical Company, Cambridge, Massachusetts.

This article is based on paper presented at the meeting of the American Chemical Society in New York, 13 Sept. 1954.

by you like dandelion tufts, piece them together, and build an ordered invention from the harassed efforts of your confreres.

The first question you will face, therefore, is not one of drafting a specification or of determining the form and scope of claims but of asking, "What must we, all of us in this new organization, do? What must we find out? What type of test and what type of developmental effort must we undertake in order to turn this suggestion into a patentable reality?"

It follows that these questions cannot be answered until the new attorney has a thorough familiarity with the field in which the products will be utilized, knows how they will be used, understands competitive procedures, and knows the scope and the direction of the prior art. When he has learned these first requisites thoroughly, quite unconsciously he will find himself able to answer many of the questions that will be raised in discussions with his confreres concerning the new idea. He may remain unaware of the change at first. Then he will come to realize that his associates are asking him questions during the preliminary stages of their thought. What he knows or what can be pumped out of him is definitely influencing the developmental course of the invention. As he realizes this, it will become a matter of pride for him to dig up all the information possible and to be able to lay before his associates the best and fullest information concerning the problem on which they are engaged.

It is natural in a small organization that such duties should fall on a patent man. He almost alone can enjoy a specious kind of isolation. Nobody will want him to call on a customer. The emergencies of the manufacturing division will rarely make any demands upon his time. He is not concerned with inventories, with credits, or with finance. In short, he has time to study, while his associates quite obviously do not; and since he has demonstrated his ability to assemble, to digest, and to apply the information he has acquired, his associates soon acquire the habit of first asking the patent department what it knows or what it can find out about the problem before much serious investigational work has been done.

Possibly I have generalized too broadly from my own experience; but it seems logical to me that in the young beginnings of a company, the patent man should assume the responsibility of assembling all the patent, scientific, and technical information that is possible. That assemblage of information begins, of course, with a working file of patents, and this cannot be assembled without long searches in Washington. I should suggest a run-through of all likely patent classes on the first search. On successive searches, I should begin to order the closest art and also to select the best illustrations of departures from that art that I could find. I believe that the working file of patents should be highly selective and highly illustrative and that no attempt should be made to make the file complete. The very volume of a complete file would swamp the capacity of any tiny patent department.

I have in mind the experience of one company. The patent counsel for that company objected to company patent men and, whenever possible, refused such companies as clients. He advised that the work could be handled properly by himself, provided that a research engineer, in addition to his usual duties, was assigned to go over all the art, become familiar with it, and then keep the counsel advised of company developments. The victim chosen began by ordering copies of all patents in every classification that he could conceive of as bearing any relation to the activities of the company. He died some 15 months later. His successor found that, although marginal notes had been written on hundreds of patents during those months, the man had made no selection or abstract file of any of the patents—he had apparently attempted to rely on his memory. His coat closet was found to be stuffed with piles of unopened packages from the U.S. Patent Office that reached nearly to the ceiling. He had stalled applications, hesitating to approach counsel while the art was still undigested. And, while his successor raced against statutory deadlines, a young woman, fortunately a trained searcher and abstractor, was put on the job of bringing order out of the chaos of prior art. But it was months before that wilderness of paper was reduced to workable dimensions.

Up to this time, this has been an era of ideas, of bench work, of pilot plant runs, and of experimental tests under customers' conditions. But then we learn what we want to make and how we must make it. And now comes the serious work of writing applications, of making them broad enough yet at the same time accurate and explicit enough to stand the test of litigation and to protect the young beginnings of the company. The company man should not attempt this work alone. Foundation patents should be the joint effort of the company attorney and experienced counsel.

Finding counsel is a tremendously important step. It requires the most careful consideration of what type of counsel the company needs and what are to be the company's plans for its patent department of the future. The company will turn to its counsel for experienced legal advice. Obviously, he must be chosen on the basis of his reputation as a lawyer, but there are other considerations to be weighed before the relationship of client and counsel, of inventor and his attorney can be as fruitful as it should be.

Actually, if a patent counsel gives thoughtful care to building up the strength of his office or a patent department head plans the personnel of his department well, he will recruit as assistants those persons whose background training fits them to understand, to study, and to progress in that art which they are employed to protect. It has always been true, when facts are in dispute, that attorneys should avoid preparing a brief or arguing a cause until they have prepared themselves so thoroughly in the background developments of the art and the implications of their client's invention that they for the moment are experts in the field. As developments have become more and more complex, the requirement that the attorney know the field thoroughly has become more and more necessary. Today it is quite unthinkable for an inventor in, for example, the fields of computers, guided missile mechanisms, or solid state physics to walk into any patent counsel's office and expect that counsel to understand the problem that he has solved. Quite probably the inventor himself has spent some years in coming to understand the problem. Unless he is prepared to pay the tremendous cost of educating his counsel, he should choose that counsel and the personnel of the counsel's office for their familiarity and success with inventions in his art. Thereafter, if there is lack of understanding between the attorney and the inventor, then one may well question how broad and how thorough the attorney's training in "classical engineering" really was. Did it give him a sound understanding of the laws of matter and a secure knowledge of how to uncover the reports of the detailed application of those laws?

But sometimes, no matter how thorough the attorney's training may be, understanding is missing, and in these instances I believe one may well question the inventor's training. Some inventors, particularly those who have received the pragmatic training of the war years, are data hounds; they dump reams of data and calculations upon an attorney's desk, saying, "Well, this is the story. You write it up." Some have no facility in language. They have never been trained to express themselves and do not understand that their entire concept must be expressed in words of the English language in order to have the legal effect that they desire in the patent specification. Some insist on the use of popularly unintelligible or confusing terminology. If they do, is the resulting lack of understanding the fault of the public or is it their own? If the attorney asks the inventor, "What do you mean by that?", does this show that the attorney is ignorant? On the contrary, can it not show that the attorney is prod-

ding the inventor to express the whole of his idea?

The attorney sometimes faces another problem. Each new art is to a degree undisciplined. Its workers push their theories forward as facts and insist that their field is *sui generis* and, until that art becomes mature, continue to insist that the old laws do not apply. This is a too convenient out for those inventors who have hold of but the tail feathers of an idea. The attorney, however, may recognize that what is put forward as a fact is really speculation. Often, when the attorney questions a pet theory, the inventor reacts by feeling that the attorney lacks proper "scientific" understanding. Sometimes, the inventor insists that his professional argot be embalmed and perpetuated in a public document. Who could read it with understanding if it were? The inventor will not try to express his thoughts intelligibly and lucidly but becomes impatient when the attorney says, "Well, let's try to phrase it this way."

To procure effective patents, the inventor and the attorney must learn to work together with complete understanding. Often it is difficult for a thing-minded inventor to understand that the job of an attorney is to translate the thoughts and expressions of a narrow and generally unknown field of endeavor into the personally minded speech and expression of society. Somehow, before a successful specification can be written, the working of a calculating machine must be made dramatic. Somehow, the problem of control of a guided missile must be made the analog of some experience common to ordinary mortals. Otherwise, a judge, who possibly cannot comprehend the mechanics of an apple corer, bewildered by verbal confusion, will cut the Gordian knot and hold the entire invention not inventive. And we must never forget the efforts of the opponent's counsel and his experts. They will do their best to show that the inventor faced no problem whatever other than the limits of his "inferior" mind.

This is a terribly difficult job, and it fails frequently, not because the attorney is deficient in training, but because there has been no true communication between the inventor and his counsel. Industrial and research establishments have this considerable advantage: they can place a person on their staff who not only is trained in patent practice but who has the background to understand the developments of the art with which the organization is concerned. These difficulties tend to disappear in established institutions where the attorney and his searcher assistants are and should be thoroughly cognizant of the art, know the inventors, know their language, and know what their expressions mean.

The ideal time for the choice of counsel, is I believe, when the prior art and technological search is reasonably complete. Very few of today's experienced counsel will attempt to make a silk purse out of a sow's ear by briefs or arguments in court. The "spectacular clarifications" of designedly indefinite language, which so impressed the courts of an earlier day, make no impression upon the courts of this technologically knowing generation. Today's counsel wants facts, a great mass of detail, and much technological information before he will advise a client. If he finds that a company patent man can give him that information promptly and accurately, it is far easier to establish rapport between counsel and the company attorney. There should be a clear division of effort. The young company attorney is a trained technologist, not an experienced lawyer. He has not had the long court experience, which alone develops a sixth sense for the selection of the soundest argument and gives a sure touch in the manner of its presentation that insures it a reasonable chance of being sustained. He should realize this. On the other hand, the counsel confronted with a new development is an amateur in the technological aspect of the problem. He should realize this and realize also that accurate knowledge of the invention, of its art, and of its surrounding technology is the forte of the company patent attorney.

The happiest kind of relationship will develop from the mutual recognition of the capacities of each man. But even if the company attorney becomes in time an experienced lawyer, even if a legal division of the company is later developed, respected outside counsel should always be retained. As the company grows, some people may enter it whose intellectual integrity appears to run on ball bearings. In a small company, enmities tend to be personal, not departmental. The internal atmosphere will remain far clearer, and a man, if told he may consult counsel, will be stopped in his plea for approval of a devious scheme if he hears counsel's serious voice say, "My clients don't do such things. I insist that you stop and understand precisely what this implies." After such words from one outside the company and beyond reach, that man will not try to kindle backfires around the company office. There is a parallel from my Army Ordnance days that illustrates this advantage. A friend, when asked why there were so many civilian consultants to the department, replied, "Because there must be someone to say 'damn' to a general."

We now enter the third phase. We have patent counsel, a good selection of patent and technological art, the beginnings of a card file, and a cross-index system. The first applications have been prepared and filed, and amendments are due. The company now has a small but formally organized research department. A steady rain of requests for aid in the searches of the research men begins as the second generation of inventions starts to appear. The attorney needs help.

I believe that his first technical assistant should be a woman. He will lose her sometime, of course, for women do get married; but he will not lose her nearly as quickly as he will lose a young man who has his heart set on becoming a patent lawyer as soon as possible.

My choice is a master or baccalaureate with distinction in the appropriate field. Holders of a doctorate, I have found, are set on teaching, become nostalgic for bench work, or are so interested in their specialty that they have lost that wide range of interest that makes a good searcher. My first assistant stayed 7 years. I had but to suggest that data must have been recorded somewhere, and she was off on its trail like a Scotland Yard inspector.

We made no attempt to build up a scientific library or collection of periodicals. New, small enterprises show a surprising tendency to nestle close to the schools that their founders attended. In our case, the great libraries of Massachusetts Institute of Technology and Harvard University are located but minutes away. Treatises, textbooks, monographs, and publications in our fields were bought by the patent department or by the research department as occasion required. They were maintained in the library of the research department. This library has now grown to one of considerable proportions, but its contents are working books, not collections. Overshadowed as we are by the great collections of the universities, we have never felt the need for a more formal establishment.

What we did establish formally was a continuing selection of patents. The weekly *Official Gazette of the United States Patent Office, British Abstracts* in appropriate fields (in the years when their publication was timely), the *Canadian Patent Office Record*, and the *Australian Official Journal of Patents* were paged as each issue appeared. From these, patents that appeared to be pertinent were ordered. Those which were found to be germane (as were most of those selected) were abstracted, filed, and cross-indexed on cards; and then the patents, with comments when necessary, were routed to the attention of the research worker concerned with the subject. United States patents were then filed by classes according to the Patent Office classification. This system seems illogical to a research man, but it is justified because preliminary searches in the department are easily coordinated with searches in Washington.

A file of selected patents is merely illustrative. It is designed to exemplify the type and trends of the art one may expect to face. If, from a search of such patents, one can point out the pertinent patents to one's Washington associate and give him their Patent Office classifications, one saves a great deal of time. Often, we obtain a thoroughgoing advisory search for less than the cost of a trip and stay in Washington. But if one files patents according to the Patent Office classification, he must be prepared to make cross-index cards under substance, process, and end-use classifications; and in our case this is done.

But just as the patent department grows in formal organization, so too the research department becomes more tightly organized. Definite projects must be assigned to particular persons, and these projects must be selected by a director with a clear plan in mind. Very early it will become apparent that the best new work in the research department is accomplished by those who are familiar at firsthand with the antecedent work on the subject. We have always held that this knowledge should not be spoon fed to the worker by others, and that the job could not be done well by the reading of a list of abstracts. Therefore, men who are assigned to a new problem are urged by the research director to study fully the antecedent publications as a preliminary to their work on the subject.

The patent searcher will help them and sometimes assembles many of the articles and journals, but we do not select the articles or make prior judgments on their pertinence. We have two reasons for this: (i) the man himself is the best judge of what he must know for understanding; and (ii) in some instances, if someone else has the responsibility for background information, the reading which we believe is necessary for understanding is just not done.

Patents are another matter. We believe that our experience in evaluating a patent's meaning, its content, and its scope is valuable and that in the case of patents we can say legitimately: "This applies to your work, and this does not."

Some patent attorneys have shown surprise on seeing our foreign docket. Because of this, I believe that it is probably an oddity of my experience that foreign patent applications assumed the importance that they did. The controlling fact was, however, that substantial foreign demand developed almost immediately and sound patent protection was necessary. It became evident that filing what was in effect a translation of the United States application in a foreign country could never give the degree of protection comparable to that which could be secured if the individual foreign case was prepared initially in the language of the nation and with the peculiarities of the nation's patent practice clearly in mind. This is not so necessary in Germany, the Netherlands, and the Scandinavian countries, where a rigorous and competent examination allows language and procedural differences to be beaten out in the prosecution of the application, but it can be fatal for registration in countries where the specification is the sole document. For this reason, applications to be filed in those nations where it is easiest to obtain patents—France, Italy, Belgium, and Argentina, for example—require initially the greatest care in preparation and draftsmanship.

This is not the place to discuss the differences in practice or the various philosophies that underlie the patent practices of the more important nations. What I want to stress here is the fact that foreign applications frequently break down because of the language barrier and because the proper expressions are not used in translations. One can check the language with a dictionary and believe that equivalent meanings in translation have been secured, and yet find that the patent coverage is not parallel. I remember one application in which the foreign examiner struck out a word and substituted another of his choice. If the change in sense had remained undetected, the patent would have been concerned with a flatbed letter printing press; instead, the invention was that of a rotary calico printing range.

It soon became apparent that the type of coverage that was needed to protect sales and operations abroad required not only that the applications be separately and individually prepared but also that a substantial amount of technological reading in the language of the country be done before one could be certain that the terms used in translation were accurate and understandable in the new language. A translator was necessary.

True philological interest and skill proved to be a more important requisite for this position than technical training. In fact, the person who proved to be the most effective was an American citizen whose father had held official positions abroad. She was a graduate of the International School at Geneva and of an American college. She was completely fluent and very well read in English, French, and German; and since her early schooling had been in the Baltic states, she spoke Russian with reasonable skill. The problem of finding exactly parallel terms and the language of the trade in which the invention was involved interested her greatly. She did a great deal of outside reading of foreign technical trade publications to be sure that the terms that were used were those that had an exactly parallel meaning to those that appeared in the parent specification. She did this reading as the invention was developing so that foreign cases could be promptly prepared.

"Safeguarding acts," import restrictions, and other government regulations made it necessary to plan very early for manufacture abroad, and as a preliminary to this, infringement and validity searches in the foreign countries were necessary. Translations of all foreign patents that appeared from these searches were made by the department translator, and these translations were placed in the general patent file. She conducted correspondence with our agents abroad in their own language. In this way, we began the prosecution of foreign cases almost as soon as the applications were filed in the United States.

Filing cases in the Scandinavian countries and particularly in the Netherlands where the examination is thoroughgoing helps in the prosecution of the United States application. The response of these foreign patent offices is so prompt that it is frequently possible to close the prosecution before the first amendment of the United States application is due in Washington. The search is so good that it is a check on our own, and one can find out how successfully he has differentiated from the references before he must respond to the American examiner's action.

Foreign subsidiary companies need local patent counsel, for there are many times when the authority of a managing director would be misunderstood if, in response to a patent or license question, he should be forced to refer the question to the parent office. Yet, if the subsidiary independently retains counsel, confusion results. Therefore, the next activity of the company attorney is possibly the selection of local counsel in those countries where operating subsidiaries are planned. In England, this can be complicated, for it entails the selection of a patent agent, a solicitor, and at least a junior barrister on retainer; but finally a system of local advisers is set up, and the foreign managers are satisfied.

Under this system, the number of cases appearing on an attorney's docket increases at a guinea pig rate, and since each case is individualized, the prosecution cannot be handled in any standardized manner. For the necessary help at this time, the company patent man needs an assistant attorney. For that assistant, it does not seem to make much difference in the long run whether one chooses a young man who has been a member of the examining corps in Washington or whether one persuades a promising, well-trained member of the research staff to enter the department and go through the tedious training of night law school while at the same time he learns patent law by working in the patent department. Both

men bring very distinctive capacities to the department, and both ultimately become effective and valuable members.

I have a feeling that, until the formal work of writing and amending cases is sufficient fully to occupy his time, it is possibly unwise to bring in as an assistant one who has spent several years in the Patent Office. Such men have been trained to handle an invention on the basis of what appears in the file and may miss the smell of an invention in the wind at a time when the research man himself may not be aware that he has hold of an important idea. On the other hand, a research worker who turns lawyer has this sense. It does not seem strange to him to work with the inventor in the embryo phase of the invention. He senses when a search will be helpful in resolving an inventor's early doubts, and often he succeeds in drawing a man out and spurring his imagination by careful questioning. On the other hand, if the load of formal cases is sufficient to make a man from the Patent Office feel that his abilities and training are being completely utilized, one of the real contributions that he can make to a department is to bring to it a sure sense of the way the Patent Office will look at the invention. If he plays the part of the devil's advocate and shows what is wrong with the specification and claims, a strong specification results and many difficulties in prosecution are avoided. And, of course, he can play a surer and more expert part in appeals and in interferences.

From this stage onward, the department grows in a more nearly conventional manner. The practice of the continuing selection of patents, of abstracting, of cross-indexing the abstracts, and of circulating the patents to members of the research staff goes on as before. More foreign patents appear in the files, for in addition to those revealed by one's own searches, patents and publications are called to one's attention by employees and patent associates abroad. The background information grows because the reports of searches list each patent and each technological article up to the date of the search. Since each new invention is usually a projection of the present activities of the company, it becomes somewhat easier, by consulting earlier search reports, to make sure that the art has been thoroughly surveyed. This work and continuing help in their own search for information are at hand for the research department. But this continuing study is not for the research staff alone. More importantly, it teaches us.

I believe that many patents fail because they give no sense of time or history and they do not attempt to fit the invention into its proper place in a developing technology. Knowledge after the event is so insidiously easy that such a patent unconsciously may be judged on the basis of the knowledge of today. The important part of the specification is to make manifest in accurate, convincing, and factual words the difference between what has now been accomplished and all that was hitherto known and to show this difference by setting forth results which even everything in the old art could not accomplish. A daily study of the art does give a sense of history and does give a sense of proportion and makes it possible to prepare a specification that does not lose its sense of time.

Additionally, familiarity with the art is a requisite for the members of the patent department who serve on the new products committee or on the patent policy committee of any company.

I have seen a form, "Disclosure and request for patent application," that is used by one of our great companies. If every question were really answered, the story revealed would become a patent attorney's dream. There are the necessary questions, of course, such as

"On what notebook pages has the work been recorded? Has the product been sold? When? What are the numbers of the laboratory and progress reports?"

Then the questionnaire goes on, and I find

"State exactly what your invention is. What problems did it solve? How was it done? Differentiate your work from the prior art. Explain its advantage in yield; in operative efficiency; the improvement of the product; in cost. Support your invention by comparing its results with those of the closest references. Give detailed examples of how your process is carried out. List closest patent and literature reference relating to this invention. State the nature and extent of your literature and patent search. Supplement this request with charts, data, memoranda, and reports."

As companies grow, departments grow, and divisions between their activities become formalized. But for men who once shared the necessity of working together intensely and cooperatively, these divisions are not barriers but guides to professional responsibilities. Somehow, such men will continue to work together no matter how large or how complicated their individual departments may become, and somehow they will infuse in their departmental members habits of working together.

I can imagine the answer that I would get from any of our research men if I should send him such a questionnaire as the one cited and require that it be completely filled out before a patent application could be begun. It would be something like this: "How many pieces of paper do you want to collect and file? You know most of the answers anyway because you helped us to find them." And this to me is the greatest satisfaction —to feel that in each new development we have had some small but recognized part in its creation.

Meanwhile machines deprive us of two things which certainly are important ingredients of human happiness, namely, spontaneity and variety. Machines have their own pace, and their own insistent demands: a man who has an expensive plant must keep it working. The great trouble with the machine, from the point of view of the emotions, is its regularity. And, of course, conversely, the great objection to the emotions, from the point of view of the machine, is their irregularity.—BERTRAND RUSSELL, Sceptical Essays (1928).

Magnets and Magnetic Field Measurements

A. L. Bloom and M. E. Packard

The discovery of nuclear magnetic resonance by Bloch and Hansen (*1*) and by Purcell, Torrey, and Pound (*2*) in 1945 ushered in a new era in the development of laboratory magnets and magnetic measurements. Not only did it become possible to measure magnetic fields with ease to a much greater degree of precision, but the magnetic resonance experiments themselves demanded magnets with much more exacting requirements of field homogeneity and stability. This article is concerned with some of the new requirements that are placed on magnetic fields by nuclear magnetic resonance and the techniques for measuring these fields. The magnets under consideration are laboratory-sized magnets used for general experimental work wherever strong fields are needed in a relatively small volume. We do not discuss magnets of highly specialized design such as large cyclotron magnets.

Precision Measurements

The measurement of magnetic fields to high precision has not always been an easy task. Until recently, the only convenient methods of measuring magnetic fields have been classical ones such as the flip coil with ballistic galvanometer and the rotating coil. These methods are still useful, but even with recent improvements in technique they are capable of an accuracy of only about 0.1 percent, assuming proper calibration. More modern instruments that are occasionally used in strong fields include Hall-effect detectors for which an accuracy of about 5 percent is claimed (*3*) and detectors that employ changes in the ohmic resistance of bismuth as a function of the magnetic field. The latter detectors, when they are calibrated and operated under constant-temperature conditions, give an accuracy of 1 part in 5000 (*4*). In weak fields, such as the earth's magnetic field, the flux-gate magnetometer (*5*), a null-measuring instrument, is capable of high relative accuracy. This type of instrument often has a noise level of less than 10^{-5} gauss, but the actual accuracy is only as good as the known value of the bias field that is used to produce the null condition.

Nuclear magnetic resonance (NMR) makes available to the experimenter an instrument that converts magnetic field measurement into frequency measurement, one of the most easily measurable quantities. If the magnetic field is H, then the resonant angular frequency ω is given by

$$\omega = \gamma H,$$

where γ is the gyromagnetic ratio of the nucleus, which is given by the expression

$$\gamma = 2\pi\mu/I\,h,$$

where μ is the magnetic moment of the nucleus, h is Planck's constant, and I is the spin of the nucleus expressed as a multiple of a half-integer. Because the frequency is related to the field only through atomic constants, which are fixed for the nuclei of any given isotope, a field-measuring instrument using nuclear magnetic resonance requires no calibration in the sense of initial comparison with a known magnetic field. Frequency standards, in the form of quartz crystal oscillators, on the other hand, are available in almost every laboratory and can easily be compared with primary frequencies broadcast by radio station WWV.

The standard techniques of inducing resonance by continuous radio-frequency excitation (*6*, *7*) work best in fields of from approximately 200 to 20,000 gauss. At the low end, the limitation is the sample volume required to give a usable signal (for fixed sample volume, the voltage induced by the nuclei in the coil is proportional to the square of the field). At the high end one finds that the fields produced by existing magnets are usually not sufficiently homogeneous to justify an attempt at a precise measurement. Recently an instrument has been built that uses proton magnetic resonance to measure weak fields such as the earth's magnetic field (*8*). Here no exciting radio-frequency field is used. Instead, the nuclei are polarized perpendicular to the earth's field by a stronger field and are then allowed to precess freely in the earth's field; it is this precession frequency that is measured directly.

The limit of the *absolute* accuracy to which a magnetic field can be measured by nuclear magnetic resonance is the accuracy to which the gyromagnetic ratio γ is known. By an absolute measurement, we mean one in which the measuring instrument is not initially calibrated in a known "standard" field. The most accurate measurement of the proton gyromagnetic ratio, by Thomas, Driscoll, and Hipple (*9*), is listed with an uncertainty of 1 part in 40,000; this is the best that can be expected of an absolute measurement by nuclear magnetic resonance at the present time (*10*). One must remember that nuclear magnetic resonance is basically a form of spectroscopy, and, as in other forms of spectroscopy, one is always uncertain about the exact location of the center of the line (or resonance) by approximately the natural width of the line. However, the natural line width in nuclear magnetic resonance spectroscopy can be so narrow that this uncertainty is much less than the uncertainty in the absolute value of γ. The natural line width is the inverse of the transverse relaxation time T_2 in a homogeneous field. One of the longest transverse relaxation times known at present is for protons in pure benzene (*11*) and is of the order of 15 to 20 seconds, equivalent to a width in magnetic field units of 2×10^{-6} gauss.

In *relative* or comparison field measurements, the situation regarding accuracy is quite different. If line width considerations are neglected, the accuracy with which one can compare two magnetic fields is limited only by the accuracy with which one can compare frequencies. Even if the lines are relatively broad, one can make assumptions regarding their structure that will remain constant from one measurement to another and so allow a reduction of the uncertainty to a small fraction of a line width. For example, in many experiments, the method of presentation introduces transient oscillations of the nuclear polarization that complicate the line shape considerably. Jacobsohn and Wangsness (*12*) have shown how simple symmetry considerations allow an exact determination of the center of the resonance even in the presence of a large number of such oscillations. Another example occurs in the case of free precession in the earth's field. Here one expects, from both experimental and theoretical considerations, that in a moderately homogeneous field the signal output will take the form of an exponentially damped sine wave. Use is made of this fact to allow measure-

The authors are on the research staff of Varian Associates, Palo Alto, California.

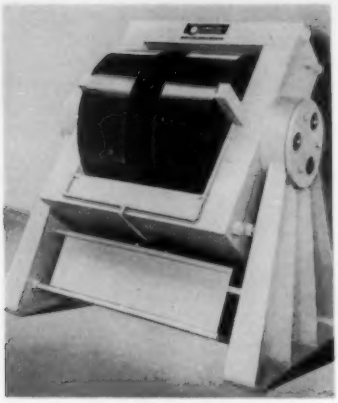


Fig. 1. Varian 12-inch electromagnet, an example of double-yoke construction.

ment of changes in the earth's field to 1 part in 250,000, limited only by the signal-to-noise ratio, and there is no reason why this precision cannot be improved in the near future.

Magnet Design

During the last few years the need for large research magnets of various geometries and precisions has led to the development and manufacture of several different types of magnets. The properties of a magnet that are of interest to the experimenter are generally the volume and homogeneity of the field, the intensity of the field, and the stability, both short- and long-time. The size of a magnet is usually described most simply in terms of the diameter of the magnet pole piece. Research-type magnets are available in sizes that range from a 4-inch diameter to a 12-inch diameter pole piece. These can be procured in permanent magnets as well as in electromagnet types.

Modern magnets usually have the general geometry shown in Fig. 1, which shows a Varian 12-inch electromagnet. The magnet is constructed with a double yoke, not so much to improve the magnetic circuit but rather to improve the mechanical stability. The magnetic forces tending to pull the pole pieces together are tremendous, amounting to about 7 tons for a 12-inch magnet at a field of 14,000 gauss. The effect of this force on a single-yoke magnet is to destroy the parallelism of the pole pieces, and thereby the homogeneity, as the field is changed. In the double-yoke magnet, only the spacing between pole tips is altered; this does not affect the homogeneity of the field.

The efficiency of an electromagnet at low or moderate fields is not particularly important. However, at higher fields it is important to attain as high a field as possible for a given power input, since cooling rapidly becomes a problem at higher currents. The general geometry of the magnet shown in Fig. 1 was chosen to produce a magnet of high efficiency compatible with good accessibility and ease of manufacture. For the production of very high fields, the fully enclosed yoke of the A. D. Little magnet shown in Fig. 2 is advantageous. Marked deviation from the geometry shown in Fig. 1 will generally result in a reduced efficiency; for this reason, most new designs of different sized magnets are uniformly scaled copies of this geometry. Scaling is the most satisfactory way to design new magnets because of the difficulty of calculating leakage flux.

The maximum field intensity attainable by a particular magnet is determined by the volume of the field and the maximum amount of heat that can be removed from the coils by the cooling system. The curves of Fig. 3, which are typical for a 6-inch magnet, show the great decrease in maximum achievable field as the gap is increased. At a ¼-inch gap, the maximum field is 18,000 gauss, while for a 6-inch gap the field is only 2000 gauss. The production of very high fields—above 15 kilogauss, where saturation of the iron becomes important—can be achieved only by the use of tapered pole pieces and narrow gaps or by the use of large input powers. For example, a 12-inch magnet that is dissipating 4.0 kilowatts will produce a field of about 13,500 gauss for a 1¾-inch gap, while tapering the pole pieces to a 1-inch diameter and a ¼-inch gap will increase the field to 38,000 gauss.

The A. D. Little magnet shown in Fig. 2 can be operated at input powers of 100 kilowatts and will produce a field of 22 kilogauss in an 11-inch diameter by 1¾-inch gap. The fact that the field is proportional to the square root of input power is a great limitation in the design and use of large electromagnets.

The coils of electromagnets can usually

Fig. 2. A. D. Little electromagnet, rotating, adjustable-height model, a type especially designed to produce very high fields. [Courtesy Arthur D. Little, Inc.]

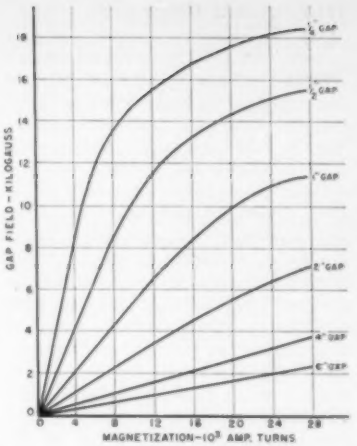


Fig. 3. Magnetic field as a function of magnetization current and gap width for the Varian 6-inch electromagnet. These curves can be used in general for any size electromagnet of the same design provided that the gap width is scaled accordingly.

be classified as having either high- or low-current windings, depending on whether the magnet current is more or less than about 2 amperes. For extremely high input powers, it is advantageous to use a high-current winding in order to achieve good heat transfer by assuring intimate copper-to-coolant contact. On the other hand, in magnet systems that require high stability, it is desirable to use a low-current winding in order to facilitate magnetic field regulation by passing the total magnet current through controlled vacuum tubes.

Permanent magnets are ideal for many applications because of their inherent stability and freedom from power supplies. Their usefulness is generally limited to producing moderate fields because the length of the Alnico-V pole pieces becomes inconveniently long at high levels. Figure 4 shows an experimental permanent magnet that has Alnico-V pole pieces each 19 inches long. This magnet produces a field of about 8000 gauss in a 1-inch by 10-inch diameter gap. This field can be increased to 14,000 gauss by tapering the pole pieces to 5-inch diameter and narrowing the gap to ¼ inch. Permanent magnets have been built that have square pole pieces measuring 12 by 12 inches; these produce a field of 7000 gauss in a 1½-inch gap.

Permanent magnets need to be energized with about 6000 ampere turns per inch of Alnico-V. The peak power is high but the average power is low because magnetization is accomplished in less than ½ second. The field is usually reduced from the maximum value in order to stabilize the system against mechanical and thermal shocks.

Magnetic Field Homogeneity

Ever since the discovery of nuclear magnetic resonance, investigators have discovered new and ramifying phenomena with each significant improvement in field homogeneity and stability. With a definition of about 1 part in a million, Arnold, Dharmatti, and Packard (*13*) discovered fine structure in the proton resonance owing to differences in electronic magnetic shielding about otherwise identical nuclei. A further improvement by a factor of 10 revealed the existence of hyperfine structure owing to indirect interactions between nuclear spins in the same molecule (*14*). Some of the most precise work to date, by Anderson (*15*) and Arnold (*16*), has involved definition of about 1 part in 100 million and has revealed hyperfine structure details to second order, indicating not only very small energy differences owing to spin interactions, but also differences in the lifetimes of the individual energy states. This is evidently not the limit to which useful information may be gained by an increase in precision. The afore-mentioned experiments seem to indicate that there is much to be learned with a precision of 1 part in 10^9 or better.

The volume over which a field is homogeneous will depend on the ratio of the pole-piece diameter to the gap width. To obtain a first approximation, well-known mathematical methods can be used to calculate the region of homogeneity for flat pole faces or for ring shims that are used to increase the field at the edges of the gap (*17*). In order to achieve good homogeneity, great care must be taken to assure that the pole faces are flat and parallel and that they are made of metallurgically uniform material. Mechanical tolerances cannot be held closely enough to insure parallelism of the pole pieces, and therefore the pole pieces must be adjusted after manufacture. This adjustment is best done by tilting the pole pieces until a nuclear magnetic resonance plot of the field shows concentric circles of constant field centered about the geometric center of the magnet. Figure 5 shows a 12-inch magnet with field measuring probe inserted. The probe is 5/16 inches in diameter and contains a $\frac{1}{8}$-inch diameter spherical water sample at the end. An example of the type of field plot made with this probe is shown in Fig. 6. This plot not only shows the concentric circles but also gives an idea of the homogeneity that can be achieved over a rather large volume.

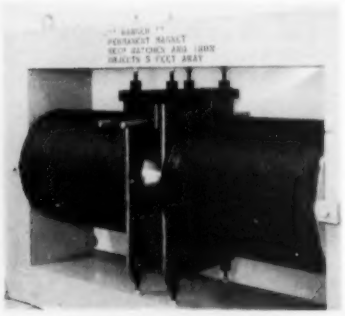


Fig. 4. Experimental permanent magnet intended to produce a 7000-gauss field in a gap 6 inches in diameter and 1.75 inches wide. The over-all dimensions of the magnet yoke are 39 by 56 by 13 inches.

For high homogeneity of 1 part in 10 million over a volume of 0.1 cubic centimeters, pole faces should be almost optically flat and free of machining marks. These conditions can be met only by lapping the pole faces and inspecting them optically for flatness. The field distribution will be dependent somewhat on the magnetic history of the magnet. For each magnet, one can develop a recipe for varying the magnetism in such a way that the end result is an optimum shaped field. The field pattern in the gap may show long-time drifts (of the order of hours) because of magnetic hysteresis of the iron. This effect will be most pronounced at the edges. Permanent magnets show much smaller regions of homogeneity than electromagnets for the same ratio of gap width to pole face diameter and must always be corrected by using ring shims.

Some magnets, although they appear perfectly symmetrical on both sides of the gap, actually show a relatively large field gradient tending to concentrate the field at one of the pole faces. The total difference in fields at the two pole faces may be as much as 0.5 gauss. This is presumably the result of differences in the permeability of the iron in the two pole pieces or of unequal windings in the two halves of the magnet.

Some experimenters have had success in the use of special shimming techniques to assist in obtaining homogeneity. Inhomogeneity can be reduced by the use of thin metallic shims placed either near the edge of the pole face as ring shims, or on the pole face in order to increase the field over small regions. The judicious use of emery paper will reduce the field over small regions and sometimes increase homogeneity. Flexibility in shimming can be achieved by the use of small coils pasted to the magnet. Different currents can be passed through the coils in order to produce quickly a number of shimming patterns. Needless to say, these techniques can be laborious and are best suited to trimming a good magnet.

In nuclear magnetic resonance experiments, the effect of a homogeneous field

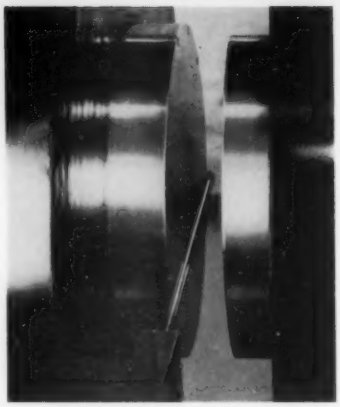


Fig. 5. Pole faces of Varian 12-inch electromagnet and nuclear magnetic resonance field-measuring probe. Note reflection of tip of the field-measuring probe in the left-hand pole face, an indication of the polish necessary for high homogeneity.

can be obtained by using a rotating sample holder (*18*). When the sample is rotated at a rate fast compared with the apparent T_2 in the inhomogeneous field, the nuclei experience all possible fields in the sample, but only the average, which is the same for all nuclei, is effective in the resonance.

Magnetic Field Stability

Whereas the problem of making the field homogeneous is mostly one concerning design of the magnet, the problem of making the field stable is primarily one of controlling external influences. For example, a permanent magnet has a negative temperature coefficient of 1 part in 5000 per degree Celsius, and an electromagnet is only as stable as the current that passes through its coils. Other influences such as external fields will affect both types of magnets.

The stability that is desired in the high-resolution nuclear magnetic resonance experiments of interest in physical chemistry is about 1 part in 10 million for a period of 30 seconds or more. At this stability, storage batteries by themselves are quite inconvenient, for the voltage "runs down" perceptibly and the resistance of the magnet increases. The most satisfactory answer seems to be a highly regulated constant-current power supply deriving its power from the alternating-current mains. Regulation is achieved by passing the magnet current through a small resistor; the resultant voltage across the resistor is compared with a reference voltage from a battery, and the difference is greatly amplified. The error voltage is then fed back by being impressed on the grids of vacuum

tubes through which the magnet current is passed. The implementation of this deceptively simple feedback system is complicated by phase shifts that lead to oscillation and by vacuum tube and circuit noise and instabilities. The drift in ordinary direct-current amplifiers is avoided by the use of choppers, or synchronous converters. All voltages in the power supply must be highly regulated, as well as the heater currents in the vacuum tubes.

At the stability level of 1 part in 10 million, the effects of completely external influences become extremely critical. Alternating-current fields from nearby transformers, metal objects being moved in adjacent laboratories, and elevators in the building—all have been known to plague the researcher in one installation or another. Another form of external influence is distortion of the magnet as a result of thermal effects or external forces. At the level of 1 part in 10 million, the pressure of one finger on a magnet yoke 6 by 12 inches in cross section produces a relatively large change in field.

A somewhat different approach to the stability problem is to devise means to control the magnetic field itself rather than just the current in the windings. This can be accomplished rather easily by using nuclear magnetic resonance to generate an error signal that is injected into the input of the power supply regulator amplifier (*19*). Many installations of this type have been made to control long-time magnet field drifts to 1 part in a million or less, and most have been highly successful. For the ultimate short-time stability, the idea loses its simplicity because the signal-to-noise ratio of the nuclear magnetic resonance control signal may be low enough to introduce noise and hunting that may be comparable to the original instabilities. Briefly, the steps needed to insure correct operation require that the control probe be in about as homogeneous a field as the research probe and that both probes be at the same field value. This puts severe homogeneity requirements on the magnet. The most stable system is one in which the greatest pains have been taken to make an intrinsically stable magnet system, with nuclear magnetic resonance feedback added as a final touch to take care of slow drifts.

An example of the type of magnet stability that one can achieve practically is shown by the following experiment. The

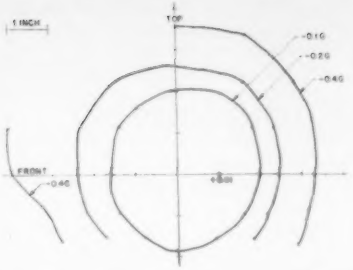


Fig. 6. Example of an experimental field plot of a Varian 12-inch electromagnet with a field of approximately 7000 gauss. The plot was taken halfway between the pole faces in a magnet that had ring shims to improve homogeneity. Contours are in fractions of a gauss with the center taken as the zero of reference. The isolated point labeled +0.01 is the field maximum.

signal of the narrow 1-milligauss proton resonance of acetone was used to monitor changes in a 7000-gauss field. With no nuclear magnetic resonance feedback, the root-mean-square magnetic field fluctuation was about 0.5×10^{-3} gauss, although occasional peaks, apparently caused by transients on the alternating-current mains, were as high as 2×10^{-3} gauss. A metal chair moved 10 feet away from the magnet, or a bench voltmeter with its small permanent magnet, 5 feet away, would each cause a deviation of about 10^{-2} gauss. In addition, there was a slow diurnal temperature effect about 10 times larger. When nuclear magnetic resonance feedback was added, the field was maintained within a range of 2×10^{-3} gauss continuously for several weeks.

There is a still different approach to the stability problem that is now being tried out in several laboratories. It involves a feedback loop in which special windings are used as pickup coils to detect changes in total flux across the gap; the loop is closed with an integrator and amplifier that passes small currents through another winding to compensate for field changes. This method appears capable of suppressing field variations, both internal and external, by a factor of 10 to 100. It seems most useful for controlling rapid variations and transients, such as those induced by power line fluctuations, whereas nuclear magnetic resonance feedback is best suited for controlling long-time drifts.

The problems involved in stabilizing a permanent magnet are different in nature from those involved in stabilizing an electromagnet. The short-time stability is excellent if external field influences can be eliminated. The long-time drift may be troublesome because of the high temperature coefficient of 1 part in 5000 per degree Celsius. However, this may be minimized by temperature lagging or thermostating. Despite the relatively large thermal coefficient, thermostating is needed only to an accuracy of about 1°C, owing to the enormous heat capacity of the magnet. Occasionally, as Wertz points out (*20*), a nearby open window is used as a control, presumably with a nearby graduate student as thermostat. The drift and the external field interferences can be reduced either by nuclear magnetic resonance or by the use of a feedback loop consisting of pickup coil, integrator, and amplifier.

References and Notes

1. F. Bloch, W. W. Hansen, M. Packard, *Phys. Rev.* 70, 460 (1946).
2. E. M. Purcell, H. C. Torrey, R. V. Pound, *ibid.* 69, 37 (1946).
3. G. L. Pearson, *Rev. Sci. Instr.* 19, 263 (1948).
4. H. B. Keller, "Precision measurement of magnetic induction with bismuth wire," UCRL-2249 (Univ. of California Radiation Laboratory, Berkeley, 1953).
5. R. W. D. Wyckoff, *Geophysics* 13, 182 (1948).
6. F. Bloch, W. W. Hansen, M. Packard, *Phys. Rev.* 70, 474 (1946).
7. N. Bloembergen, E. M. Purcell, R. V. Pound, *ibid.* 73, 679 (1948); R. V. Pound and W. D. Knight, *Rev. Sci. Instr.* 21, 219 (1950).
8. M. Packard and R. Varian, *Phys. Rev.* 93, 941 (1954).
9. H. A. Thomas, R. L. Driscoll, J. A. Hipple, *ibid.* 78, 787 (1950).
10. The gyromagnetic ratios of other nuclei have always been measured relative to the proton or to some intermediate nucleus.
11. G. Chiarotti, G. Cristiani, L. Giulotto, *Nuovo Cimento Ser. 10*, 1, 863 (1955). Their measurements give $T_1 = 19$ seconds in benzene free of dissolved oxygen; theory predicts that T_2 should be only slightly less. Preliminary free precession experiments at Varian Associates indicate that T_2 of pure benzene is at least 10 seconds.
12. B. A. Jacobsohn and R. K. Wangsness, *Phys. Rev.* 73, 942 (1948).
13. J. T. Arnold, S. S. Dharmatti, M. E. Packard, *J. Chem. Phys.* 19, 507 (1951).
14. H. S. Gutowsky and D. W. McCall, *Phys. Rev.* 82, 748 (1951); H. S. Gutowsky, D. W. McCall, C. P. Slichter, *ibid.* 84, 589 (1951).
15. W. A. Anderson, thesis, Stanford Univ., 1955.
16. J. T. Arnold, thesis, Stanford Univ., 1954.
17. M. E. Rose, *Phys. Rev.* 53, 715 (1938).
18. F. Bloch, W. A. Anderson, J. T. Arnold, *ibid.* 94, 496, 497 (1954).
19. M. E. Packard, *Rev. Sci. Instr.* 19, 435 (1948).
20. J. E. Wertz, "Nuclear and electronic spin magnetic resonance," U.S. Air Force Rept. OSR-TN-55-203 (School of Chemistry, Univ. of Minnesota, 1955). This report discusses the problem of obtaining a homogeneous field in considerable detail.

Nourished by knowledge patiently won, bounded and conditioned by co-ordinate reason, the imagination becomes the prime mover of scientific discovery.—JOHN TYNDALL.

Applications of Radioactive Isotopes to Measurements

Robert T. Nieset

New applications of radioactive isotopes and radioactive detection procedures to measurement and control processes are described nearly every day. The research and control techniques, both depending on rapid, accurate measurement that is made possible by the application of radioactivity, are among the greatest advantages that have been conferred on the scientific and technical community of the atomic age. The limitations of measurements are the interferences they impose on a system under investigation. The final and inescapable limitation is expressed by the indeterminacy principle. The great advantage of the use of isotopes and radioactivity in measurement is the very small interference with normal processes—that is, the minimal disturbances of the system—that they introduce.

Evidence of the high sensitivity obtainable is the great dilution that can be tolerated in the employment of a radioactive isotope as a tracer. Dilutions of 10^6 are not uncommonly encountered. Quantities of a radioactive material as small as 10^{-4} microcuries can readily be measured. The number of moles represented by an activity of 10^{-4} microcuries depends on the disintegration constant of the particular isotope. For an isotope with a short half-life, such as sodium-24, the number of moles represented by 10^{-4} microcuries is 0.5×10^{-12} micromoles.

In addition to this, the gamma radiation from most radioactive isotopes is weakly absorbed by matter; therefore, this type of radiation can be measured or detected through intervening barriers such as body tissue, tanks, pipes, or reaction vessels. Many types of measurements that would otherwise require the introduction of disturbing probes, transducers, or sampling cannulae can be carried out with greater ease and much less uncertainty.

The interactions with matter of the characteristic radiations frequently provide facile means for determining important characteristics of the intervening matter or absorber itself. Thus, the differential absorption of gamma rays provides a means of radiography; the absorption of beta radiation provides a means of measuring density or thickness; and measurements of neutron recoil or secondary radiation provide a means of determining chemical or physical composition. All such measurements can be made with relative ease and simplicity.

The author is director of the biophysics laboratory at Tulane University.

Detection and Measurement of Radiations

The four basic means of detecting and measuring the characteristic radiations are (i) photographic emulsions, (ii) ionization chambers, (iii) Geiger counters, and (iv) scintillation counters.

The alpha, beta, and gamma radiations from radioactive materials all expose conventional photographic films and papers. The use of this means of detection to obtain a pattern of the distribution of a radioactive material or a picture of the differential absorption of the radiation is quite obvious. This is analogous to x-ray radiography with the additional possibility of autoradiography when the system is made to contain its own radiation source. Quantitative use of film is of relatively limited application, but use of it is made in monitoring devices for personnel protection and for measurements of radiation in relatively inaccessible places where electronic detection equipment would be cumbersome.

The radiations from radioactive materials produce ionization in gases. This is the basis for the ionization chamber. Some method for measuring the conductivity of a gas-filled chamber is provided. Since conductivity depends upon ionization, an electric measurement of the number of ions formed within the enclosed gas space is thereby obtained. The product of the number of ions and the energy required for the formation of each ion gives a measure of the energy absorbed from the beam by the ionization chamber. If the absorption characteristics of the chamber are known, the energy of the beam under observation can be determined. For any particular isotope, this energy will be a function of the number of radioactive disintegrations that take place in the source. Hence the concentration of the radiating source or tracer element can be determined. Primarily, the ionization chamber measures some fraction of the total energy of the radiation emitted by a radioactive source, but if the characteristics of the chamber, the geometric efficiency, and the nature of the source are likewise determined, the absolute strength of the source, or its concentration, may be readily calculated. In most applications, however, it is only necessary that these conditions be reproducible or be standardized. Relative measurements of concentration or radiation intensity suffice to provide the desired information for most tracer studies.

The most widely used detector is the Geiger-Müller counter. The Geiger counter tube may be looked upon as an ionization chamber with concentric electrodes at such a potential that the electric field will produce an avalanche of secondary ions whenever a primary ionization occurs. It operates as a gas filled diode below the potential of continuous discharge. It is a triggering device in which a voltage pulse is produced by a discharge initiated by an ionizing particle. Quenching of the discharge is controlled by the external circuit and by the pressure and nature of the gas used to fill the tube. It acts, therefore, as a particle detector or counter. The number of output voltage pulses in a specified time is a measure of the number of primary ionizing encounters that have taken place within the tube in that period of time. Over a quite wide range of output pulses or counts, the Geiger counter yields a number of pulses directly proportional to the number of disintegrations that occur in the radioactive source being measured. It provides a good means for determining relative concentrations provided that standardized conditions of geometry and efficiency are observed.

A more recent development for the detection of radioactivity is the scintillation counter. It depends on the production of fluorescence in a crystal by the absorption of ionizing radiation. When electrons drop into vacancies in the shells left by the production of ion pairs, the energy liberated appears as visible light. It was by the visible counting of these tiny flashes of light in zinc sulfide phosphors that much of the original work in nuclear physics was done. By this method, Rutherford obtained the data that demonstrated the nuclear structure of the atom. The method fell into disuse until the development of photomultiplier tubes provided a sensitive electronic means for

counting the little flashes of light or scintillations. The most widely used phosphor today is a crystal of sodium iodide activated with thalium.

Two great advantages are offered by the scintillation counter. Its efficiency for the detection of gamma radiation is much higher than that of the Geiger counter. A Geiger counter will detect about 1 percent of the gamma ray photons that enter its sensitive volume; a scintillation counter will detect 10 to 15 percent of the gamma radiation it absorbs. The second advantage is that the scintillation counter produces a pulse of an amplitude that is proportional to the energy of the absorbed photon. The crystal must be thick enough to absorb all the gamma radiation that falls on it. It acts, therefore, not only as a detector of photons but also as a device for the measurement of the photon energy. It provides the particle-counting and -detecting advantages of the Geiger tube with the energy-measuring advantages of the ionization chamber.

Radioactive Isotopes as Tracers

The most versatile uses of isotopes are as tracers in the investigation of chemical and physical processes. The concept of the tracer technique has derived from the early investigations of George Hevesy, who used the naturally occurring radioactive isotopes of lead and bismuth as early as 1920 (*1*). He made use of radium D and thorium B in studies of both chemical exchange reactions in solution and the self-diffusion of metals. Later, by use of radium D and E as tracers, he studied the distribution of lead and bismuth, respectively, in animals. The discovery of artificial radioactivity by Joliot and Curie in 1934 opened the way to a great expansion of the use of isotopes as tracers. The development of the cyclotron made it possible to produce relatively large numbers of isotopes of many of the elements. The nuclear energy program of World War II, culminating in the bomb and the nuclear reactor, made possible the production, in relatively large quantities, of radioactive isotopes of nearly all the elements. The needs of the nuclear energy program also stimulated the rapid development of measuring equipment for the detection and measurement of radioactivity; the continuing needs of the U.S. Atomic Energy Commission in particular have led to the commercial production of numerous adequate instruments for use in the general field of radioactivity.

The basic property of isotopes that makes them useful as tracers is the chemical identity of the isotopes of the same element. The characteristic physical property that serves to identify a particular isotope is independent of the chemical transformations which the element may undergo. The chemical properties depend upon the number and arrangements of the extranuclear, planetary electrons. The number of these electrons is determined by the number of protons and is equal to the atomic number Z of the element. The neutrons contained in the nucleus contribute mass but no electric charge; the number of protons and neutrons together gives the mass number A of a particular nuclear species. Species that contain the same number of protons and hence the same number of extranuclear electrons but differ in the number of neutrons are called isotopes. There is thus a mass difference between the various isotopes of any element. The statement that chemical properties of isotopes of a given element are identical is not, therefore, completely true. The isotopes of a given element all go through the same reactions and form the same compounds. There are differences, however, in reaction rates, which depend upon differences in isotopic mass. Ordinarily these differences are not great enough to be significant, but they may assume importance in some systems, particularly systems that are not in equilibrium.

One of the simplest uses of an isotopic tracer is for the quantitative analysis of a mixture of related substances; the method has been called "isotope dilution." Isotope dilution analysis eliminates the necessity of quantitative isolation.

To determine the concentration of a single component of a mixture by this method, an accurately weighed amount of compound to be measured, marked with an isotopic label, is added to the mixture. After adequate assurance that complete mixing has taken place has been obtained, a sample of the compound is isolated and purified by appropriate means. The dilution of the tracer isotope is measured and the amount of compound originally present in the mixture Q, is calculated from the following equation.

$$\frac{Q+q}{q} = \frac{a_1}{a_2},$$

or

$$Q = q\left(\frac{a_1}{a_2} - 1\right).$$

The quantity of the component originally present in the mixture is Q; the labeled sample added is q; the specific activity of the added tracer is a_1; the specific activity of the labeled component after complete mixing is a_2. Specific activity is taken to mean radioactivity per unit volume or unit mass.

Synthesis of Tagged Components

The necessary first step of synthesizing the tagged component may be difficult. A modification of procedure made by Keston, Udenfriend and Cannan (*2*) points the way to simplification of the synthetic procedure and adapts the process to the analyses of very small amounts of materials. In their procedure, a mixture of amino acids was treated with *p*-iodophenyl sulphonyl chloride labeled with iodine-131. Quantitative conversion of all the amino acids to the "pipsyl" derivatives was obtained. Excess of unlabeled pipsyl derivative of the desired amino acid was added to the mixture in known amounts, then isolated and purified. The ratio of its specific activity to that of the original pipsyl chloride used provided data for the determination of the relative amounts of amino acids in the protein hydrolysate from as little as 1.3 milligrams of enzyme protein. An exact set of equations that describe applications of isotopic dilution has been published by Gest and his coworkers (*3*).

Many times it is desirable to study not only the constituents but also the kinetic properties of a system. Only tracer studies of systems involving first order reactions are considered here, even though a great extension of the general technique is obviously possible. When it is known that the reactions in a system are of the first order and irreversible; that no distinction is made between labeled and unlabeled substances of the same chemical or physical form; that the participation of molecules is purely random and that there is no distinction between old and newly formed reactants; that the system remains in a steady state except for the concentration of tagged molecules; and that the mixing time is short compared with the time in which changes in concentration of the tracer take place—then the application of tracer methods and the mathematical description are comparatively simple. In the system, there may be transfers of substances from one region to another; synthesis or degradation of material; transitions from one chemical form to another; and movement from one specified volume, tank, or compartment to a succeeding one. These changes may be generally described as changes of phase.

The addition to a system meeting the afore-mentioned specifications of a small amount of material homologous to that already present, but labeled with a radioactive isotope, will not disturb the system. The tagged component will undergo the same processes or changes of phase as the normal homolog. The tracer atoms or molecules themselves, however, will not be in equilibrium. The changes in concentration of the tagged material are

described by the same equations that govern the changes in phase of the unlabeled material normally present. Since the tagged molecules are distinguishable to the observer, their changes in concentration can be measured to yield the parameters in the pertinent equations.

The concentration of tracer substance as a function of time in any phase is given by the equation

$$X = a_1e^{-k_1t} + a_2e^{-k_2t} + \ldots + a_ne^{-k_nt}.$$

If X, the concentration of the labeled substance, is measured at suitable intervals of time t, the parameters a_j and k_j can be evaluated. In practice, the periodic measurements of X are plotted as the ordinate on semilogarithmic paper against a linear time base as the abscissa. The resulting curve is analyzed by subtracting out, as straight lines, the separate exponential components. By extrapolating each component back to zero time, the values of a_j are obtained. The value of k is easily determined from the half-time of each component by the relationship

$$k = \frac{\ln 2}{T_{\frac{1}{2}}}.$$

The half-time ($T_{\frac{1}{2}}$) is the period in which a_j is reduced by one-half and can generally be obtained by inspection.

$$k_j = 0.693/T_{\frac{1}{2}}.$$

The physical or chemical significance of a_j and k_j is often not obvious until other phases of the system have been investigated.

Three simple cases are presented in some detail: (i) output flow from a single phase in the steady state; (ii) constant input rate and exponential output of tracer substance; and (iii) transfer of tagged substance between phases.

Output flow from a single phase in the steady state. It is assumed that the total quantity of substance in the phase remains constant and that input and output in grams or cubic centimeters per second are equal and constant. After labeled substance has been added and completely mixed to make the specific activity in the phase at $t = 0$ equal to A_0 microcuries per gram, the specific activity in subsequent time decreases exponentially.

$$A_t = A_0e^{-kt}.$$

The parameter k in this application has the physical significance of the fractional amount of the total substance in the phase that is replaced in unit time. It can be determined from the plotted measurements as described in a previous paragraph.

If Q is the total amount of substance and r is the rate of input or outflow, then

$$k = \frac{r}{Q}.$$

The reciprocal,

$$\frac{1}{k} = \frac{Q}{r},$$

equals the time required for a replacement of the substance by an amount Q. This frequently is called the turnover time. The value of Q may be determined by isotope dilution at $t = 0$. From Q and k the value of r can be determined.

Constant input rate and exponential output of tracer substance. When the input rate of a tagged substance into a single phase is constant at a value of q microcuries per unit time, but the output rate is proportional to the concentration, the specific activity A_t is given by the expression

$$A_t = \frac{q}{kQ}(1 - e^{-kt}).$$

As in the previous case,

$$k = \frac{r}{Q},$$

where Q is the total quantity of substance in the phase and r is the output rate.

Transfer of tagged substance between phases. A rate problem that is of frequent occurrence is that of the transfer of a tracer from one phase to one or more others. Again a steady state is assumed, with a constant amount Q of the unlabeled material in each phase, and constant input and output r.

It is considered that material from initial phase 1 flows directly into phases 2, 3, . . . , n. Rates and total amounts for each phase are given by the expressions

$$k_1 = \frac{r}{Q}; \; k_2 = \frac{r_2}{Q_2}; \; k_n = \frac{r_n}{Q_n}.$$

At $t = 0$, the specific activity of phase 1 is raised to A_0 microcuries per gram. Its subsequent activity is

$$A_1 = A_0e^{-k_1t}.$$

The specific activity A_2 of phase 2 is zero at $t = 0$, but after a time t,

$$A_2 = A_0\frac{Q_1}{Q_2} \cdot \frac{k_1}{k_2 - k_1}(e^{-k_1t} - e^{-k_2t}).$$

The activity in phase 2 increases to a maximum in the time

$$t_{max.} = \frac{1}{k_1 - k_2}\log\frac{k_1}{k_2}.$$

Thereafter, the activity decreases at a rate equal to the smaller value of k.

As k_1 approaches k_2, the equation for A_2 becomes indeterminate and a limiting form must be used:

$$A_2 = A_0\frac{Q_1}{Q_2}kte^{-kt}.$$

These three simple cases are merely indications of the great power of tracer methods in measurement procedures. More detailed discussions are to be found in the works of Siri (*4*), Sacks (*5*), and Solomon (*6*), together with references to more advanced discussions and applications.

Special Measuring Techniques

Many special measuring techniques are made possible by the interactions with matter of the radiations emitted from a radioactive source. Typical of these is the beta gage.

Measurements with the beta gage are made in either of two ways: (i) by the absorption of the radiation as it passes through a material or (ii) by the back scatter of the radiation from the material. The gage is generally useful for measuring thickness of moving materials in fabrication or concentrations of solutions in chemical processing. A quantitative analysis of the performance of the beta gage has been made by Zumwalt (*7*). A summary of industrial experience has been compiled by Foster (*8*). Improvement in quality control has been consistently obtained.

The gamma radiation provides an especially valuable tool for measurement because it is weakly absorbed. It makes possible the use of external detectors to measure the distribution of a tracer or changes in tracer concentration in closed or inaccessible systems. An illustration of this, now in widespread use, is the technique of measuring the functioning of the thyroid gland by observing, with an external counter, the concentration of an orally administered dose of radioactive iodine.

A further example of a technique in which advantage is taken of the external detection of radiation is a method for measuring the velocity profile of a fluid that was devised by Richardson and coworkers (*9*). The lower part of a vertical tube is filled with a tracer solution, the upper part with tracer-free solution. The flow is brought quickly to constant velocity. An external detector downstream from the interface measures a continuous decrease in the activity as the tracer is displaced. Since flow is more rapid in the center, the detector sees a continuous decrease in tracer layer thickness.

If x is the distance from the initial interface to the detector downstream, the velocity of flow v is given by the expression

$$v = \frac{t}{x}.$$

The relationship between velocity and tracer layer thickness is

$$v/v_0 = 4[y/d - (y/d)^2],$$

where v is velocity at the inner edge of the y layer, v_0 is the velocity at the center

of the stream (maximum velocity), and d is the diameter of the pipe. The counting rates at the detector are given by the expression

$$C/C_0 = 4[y/d - (y/d)^2],$$

where C_0 is the rate with the tube full of tracer and C is the rate at time t after flow has started.

Conclusion

The applications of radioactive isotopes reviewed here are of the simplest type, but they indicate the powerful contributions that the development of nuclear physics and engineering have brought to the whole science and art of measurement. These advantages reduce to two major improvements. The first is the increased ability to make observations without grossly disturbing the properties of the system that is being investigated. The second improvement is relief from the necessity of isolating the system to the extent that conventional procedures would otherwise require. It is interesting that the atomic age, which offers tremendous extension of man's muscle, should also open new windows for his observation of himself and his world.

References

1. G. Hevesy, *Radioactive Indicators* (Interscience, New York, 1948).
2. A. S. Keston, S. Udenfriend, R. K. Cannan, *J. Am. Chem. Soc.* 71, 249 (1949).
3. H. Gest, M. D. Kamen, J. M. Reiner, *Arch. Biochem.* 12, 273 (1947).
4. W. E. Siri, *Isotopic Tracers and Nuclear Radiations* (McGraw-Hill, New York, 1949).
5. J. Sacks, *Isotopic Tracers in Biochemistry and Physiology* (McGraw-Hill, New York, 1949).
6. A. K. Solomon, *Biological and Medical Physics* (Academic, New York, 1953), vol. 3, pp. 65–97.
7. L. R. Zumwalt, *Nucleonics* 12, 55 (1954).
8. N. S. Foster, *Nucleonics* 12, 64 (1954).
9. F. M. Richardson *et al.*, *Nucleonics* 13, 21 (1955).

Mechanical Translation

New Challenge to Communication

Jacob Ornstein

One of the thorniest problems in present-day communication is the translation of important writings, especially in the fields of science and technology, from one language to another. The machine age has done little to alter the translation process, which today, as it was centuries ago, must be laboriously performed at considerable expense by human beings. Moreover, growing concern over the dangerous lag between the appearance of important works in other languages and their translation into English and other tongues has within the past decade focused serious attention on the problem of mechanical translation. Until recently, however, mechanical translation has remained one of those human dreams the realization of which was relegated to some point in the unpredictable future.

It was with the development of the electronic computer that real hope came to be felt concerning the possibility of mechanical translation. The man who first envisioned the possibility of translation by electronic means was apparently Warren Weaver, director of the Natural Sciences Division of the Rockefeller Foundation. First of all in 1945, and more concretely in a memorandum dated 15 July 1949, Weaver raised the question of the feasibility of designing a computer-like machine capable of translating from one language to another. This memorandum was circulated among a number of linguists and scientists; their reactions ranged from high optimism to complete skepticism. Weaver's concepts, nevertheless, aroused considerable interest and stimulated preliminary research in the field.

The problem of mechanical translation is being approached by a growing number of scholars, although much of the research is in the realm of speculation and theory. Among mathematicians, one may mention such figures as Yehoshua Bar-Hillel, formerly of Massachusetts Institute of Technology and now of Hebrew University, whose articles on mechanical translation were accorded considerable space in the 5 April 1954 issue of *Time*, the weekly news magazine. Important research is being carried on at Massachusetts Institute of Technology by Victor H. Yngve of the Research Laboratory of Electronics and William N. Locke, professor of modern languages. Anthony Oettinger of Harvard University's Computation Laboratory has also been conducting experiments. Erwin Reifler of the University of Washington has concerned himself with the elaboration of a mechanical dictionary. An active group, headed by William Bull and Victor Oswald, is working on problems of mechanical translation at the University of California at Los Angeles.

The first successful experiment in performing mechanical translation was the result of a joint project undertaken by Georgetown University's Institute of Languages and Linguistics, Washington, D.C., and the International Business Machines Corporation. Considerable publicity followed their demonstration at I.B.M. headquarters in New York on 7 January 1954 of the translation of more than 60 sentences from Russian into English. An invited group of government officials, linguists, and scientists watched a typist who knew no Russian type the sentences, which had been transliterated into the Roman alphabet, on an electric card punch and feed them into the "electronic translator," which produced accurate English translations. The sentences were from the workaday fields of science, technology, communications, and international affairs. The following are a few examples of the transliterated Russian sentences and the English equivalents:

Myezhdunarodnoye ponyimanyiye yavlyayetsya vazhnim faktorom v ryeshyenyiyi polyityichyeskyix voprosov.

International understanding constitutes an important factor in decision of political questions.

Dorogi stroyatsya yiz byetona.

Roads are constructed from concrete.

Komandyir poluchayet svyedyenyiya po tyelyegrafu.

A commander gets information over a telegraph.

Vyelyichyina ugla opryedyelyayetsya otnoshyenyiyem dlyiny dugi k radyiusu.

Magnitude of angle is determined by the relation of length of arc to radius.

Obrabotka povyshayet kachyestvo nyeftyi.

Processing improves the quality of crude oil.

It is revealing to consider in some detail the background of the Georgetown-

The author is on the staff of the U.S. Department of Agriculture Graduate School.

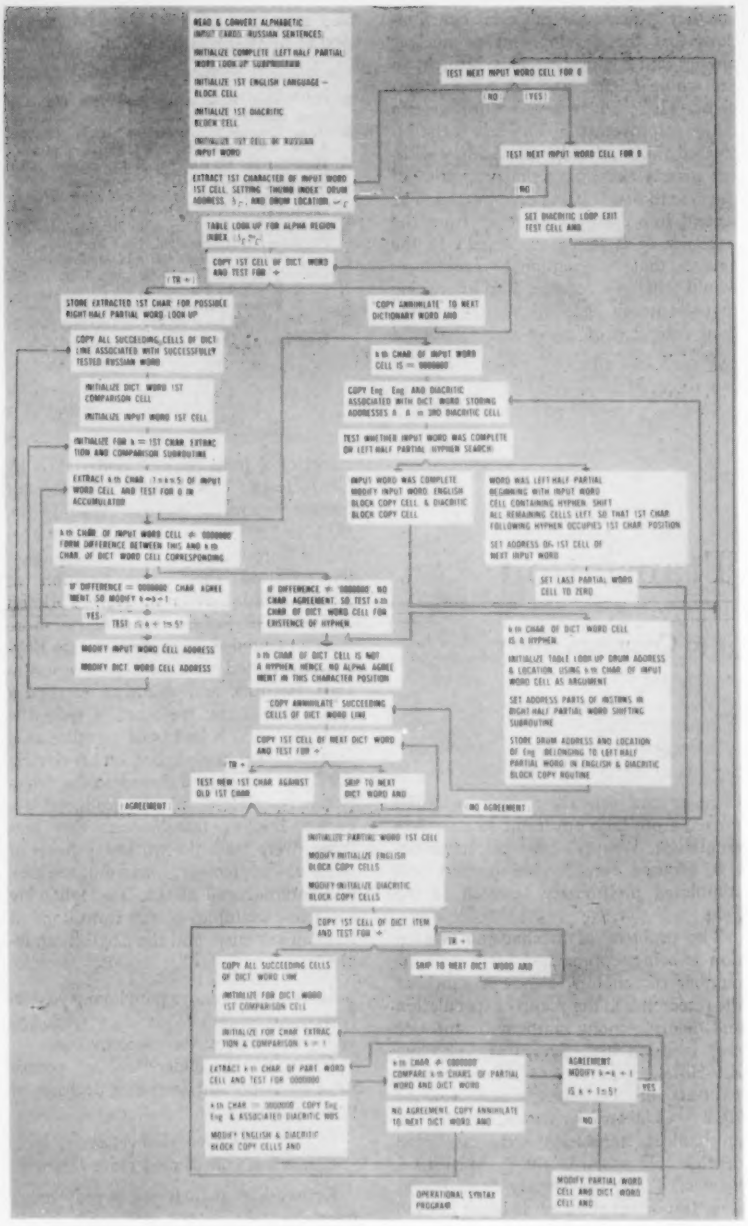


Fig. 1. Dictionary syntax flow chart showing the logical procedure followed by I.B.M.'s 701 electronic data-processing machine in translating from one language to another.

I.B.M. experiment, its accomplishments, and the implications that it has for the future. Among other things, it is the account of an experience in which the humanities, represented by languages, joined forces with science and technology to solve a problem in human communication.

Early in 1952, Leon Dostert, director of the Georgetown University Institute of Language and Linguistics, was invited to participate in the first Conference on Mechanical Translation, which was held with the support of the Rockefeller Foundation at Massachusetts Institute of Technology. Highly skeptical of the feasibility of any such process, Dostert prepared a talk expressing his grave doubts. However, on his way to Cambridge, he began to question his own skepticism and destroyed his script. Arriving in a more receptive mood, he was induced by the proceedings of the conference to believe that nothing would ever be accomplished unless the matter went beyond the realm of mere speculation.

Armed with pertinent linguistic data, Dostert approached the International Business Machines Corporation, where he was accorded a sympathetic reception. Thomas J. Watson, chairman of the board, authorized and encouraged the project, which was conceived in terms of a trial run of a glossary of 250 Russian words. Cuthbert C. Hurd, now I.B.M.'s director of electronic data-processing machines, and Peter Sheridan, mathematician, concerned themselves with the technical and scientific aspects of the undertaking.

On the linguistic side, it was Dostert who was the moving force behind the experiment. He largely delegated the problems of linguistic analysis to Paul Garvin, anthropologist and linguist who is acquainted with a wide range of European and other tongues. Two years of close collaboration followed in which the most recent findings of linguistics and of mathematical logic were harnessed to find a solution to the problem.

The demonstration that took place in January 1954 represented the successful completion of the first phase of the joint experiment as well as tangible proof that machine translation is possible. The enthusiasm of the publicity surrounding the demonstration tended to create the impression that the problems of automatic translation had largely been solved. This does not correspond to the reality of the situation. Much still remains to be done. Dostert, wishing to curb the tendency to describe the results of the demonstration in excessively glowing terms, has repeatedly referred to it as the "Kitty Hawk" of the experiment.

At the present stage of development, the translation machine actually consists of an I.B.M. data-processing machine type 701, which is known popularly as the "mechanical brain" and which is capable of performing numerous arithmetical and logical operations at very great speeds. To the layman, it looks like an assortment of 11 complicated electronic units, not unlike modern kitchen ranges, connected by cables to function as a unit.

The translator has a vocabulary of 250 words. To prepare it for the experiment, each word was punched on a punch card, together with its English equivalent or equivalents and three codes that were designated first, second, and third. The information on the punch cards was stored in the form of plus and minus charges on the magnetic drums. This occupied the space of 6000 "machine words" of 36 binary digits each. Following this, the programs developed for translation were run into the machine.

Each instruction written in ordinary English had to be converted into terms of detailed programs for the individual computations of the machine. A single sentence of verbal instructions might require 100 computations on the part of the machine. The program steps for the machine, prepared by Sheridan, totaled about 2400. The dictionary syntax flow chart shown in Fig. 1 gives an idea of what the programming represents.

The designers also elaborated three codes that indicated to the machine which of the six rules of operational syntax applies to each word inserted for translation. These rules, or rule-tags, which were developed by Garvin, govern the transposition of words, choice of meanings where there are several alternatives, omission of unnecessary words, and insertion of necessary words. Their role, therefore, is to order the units so that the words will not come out a mere jumble.

Let us take a few examples of the functioning of the rules. The Russian words *gyeneral mayor* indicate a rank roughly equivalent to major general. Obviously the two words must be reversed. The switch is assured in advance by attaching the rule-tag 21 both to the Russian word *gyeneral* and to its translation in the bilingual glossary stored in the machine, and by attaching rule-tag 110 to the Russian word *mayor* and its translation. According to the stored instructions, whenever a rule-tag 110 is encountered in the glossary, it is necessary to go back and look for a rule-tag 21. If a 21 is found, the two translations must be printed in reverse order. Thus the translation *major* of *mayor* is printed before the translation *general* of *gyeneral*.

One more illustration is worth noting. The Russian word *o* can mean either *about* or *of*. In the Russian-English glossary *nauka* has affixed to it the rule-tag 242 and *o* carries the rule-tag 141. The instructions indicate to the machine that whenever rule-tag 141 is encountered, it is necessary to go back and search for 241 or 242. If 241 is found, the first English translation is selected and both words are printed in the order in which they appear in the Russian sentence. If 242 is encountered, the second English meaning is selected. Consequently, the computer reads the 141, looks for and finds 242, chooses the second meaning given for *o*, which is *of*, and prints correctly *science of*.

Table 1 contains the three codes and the six Garvin rules of syntax; Fig. 2 illustrates how a source sentence is translated, analyzed, and arranged in correct English word order by the converted I.B.M. 701 electronic data-processing machine.

The Russian language was chosen by the designers, but any one of the 2000-odd languages of the world might have been chosen. One reason for the selection of Russian was its strategic importance; another was the fact that there is a relatively small number of persons competent to handle Russian, while the accumulation of untranslated works in that tongue continues to increase at an alarming rate. This accumulation constitutes an overflowing reservoir of data about the Soviet Union—books, newspapers, and journals available in Russian to any interested party. Moreover, the Georgetown linguists felt that in view of the highly inflected nature of the language, which is similar to Greek and Latin in its multiplicity of endings, a mechanical translator capable of handling Russian would yield significant experience for dealing with other complicated languages.

A preponderance of sentences from scientific and technical fields was chosen for the trial run, not only because of obvious timeliness, but also because writing in scientific and technical fields is done with words having highly specialized and precise meanings. Hence, if a word appears in a certain context, the chances of its having a single, unambiguous meaning are extremely high. The same possibilities for accurate prediction occur in other fields of technical writing such as medicine and engineering. Consequently, the Georgetown linguists assume that electronic translation will begin with separate dictionaries for each technical area; as experience with these areas grows, enough will be learned eventually to permit accurate translation of our common everyday language as well.

Two major problems exist for designers of mechanical translators. The first is that of reducing the number of synonyms of any given word for storage in the mechanical dictionary. This is rendered difficult by the fact that compilers of conventional dictionaries have persisted in giving an unnecessarily large number of equivalents for each entry. The experience with the electronic translator has indicated that improved selective techniques based on the principles of present-day linguistics will help provide answers to this problem.

The second difficulty is that of "operational syntax," which in mechanical translation parlance means the obtaining of an intelligible output sequence from an input with a different sequence of elements. This can be solved only by preparing detailed linguistic instructions that in turn must be converted into electronic instructions to the computer. Only by such means can machines produce intelligent translations relatively free of ambiguities.

The converted 701 computer with its 250-word vocabulary and six Garvin rules of operational syntax is still too limited to be effective for full-scale translation. This means that designers must

Fig. 2. Diagram illustrating how a source sentence is translated, analyzed, and arranged into the target sentence in correct English word order by the I.B.M. 701 electronic data-processing machine. See Table 1 for rules of operational syntax.

Table 1. Rules of operational syntax to accompany Fig. 2

Rule 1: Rearrangement. If first code is 110, is third code associated with preceding complete word equal to 21? If so, reverse order of appearance of words in output (that is, word carrying 21 should follow that carrying 110); otherwise, retain order. In both cases, English equivalent I associated with 110 is adopted.

Rule 2: Choice—Following Text. If first code is 121, is second code of the following complete, subdivided, or partial (root or ending) word equal to 221 or 222? If it is 221, adopt English equivalent I of word carrying 121; if it is 222, adopt English equivalent II. In both cases, retain order of appearance of output words.

Rule 3: Choice—Rearrangement. If first code is 131, is third code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to 23? If so, adopt English equivalent II of word carrying 131 and retain order of appearance of words in output; if not, adopt English equivalent I and reverse order of appearance of words in output.

Rule 4: Choice—Previous Text. If first code is 141, is second code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to 241 or 242? If it is 241, adopt English equivalent I of word carrying 141; if it is 242, adopt English equivalent II. In both cases, retain order of appearance of words in output.

Rule 5: Choice—Omission. If first code is 151, is third code of following complete word or either portion (root or ending) of following subdivided word equal to 25? If so, adopt English equivalent II of word carrying 151; if not, adopt English equivalent I. In both cases, retain order of appearance of words in output.

Rule 6: Subdivision. If first code associated with a Russian dictionary word is ***, then adopt English equivalent I of alternative English language equivalents, retaining order of appearance of output with respect to previous word.

embark upon a new phase of development, seeking both to amplify the vocabulary and to increase the ability of the machine to handle a wider range of operational syntax. The six rules will have to be vastly increased in number. Dostert estimates that about 100 rules would be needed to govern a vocabulary of 20,000 words. All this will require a great deal of additional linguistic research, as well as a special study, from the mechanical-translation point of view, of the source language vis-à-vis the target language. From the technical standpoint, this will involve increasing the machine storage and possibly the devising of special circuits. It will be necessary to analyze translation samples of increasing length and complexity and to adjust the results progressively after each analysis. The validity of the programming must continually be tested against machine equipment.

Looking realistically at the electronic translator, its developers recognize that the I.B.M. 701, which costs about $500,000, is "overdesigned" for language translation; it has many functions not essential to this task that were built in to solve problems in astronomy and physics. The bulkiness of the 11 units, which occupy roughly the same area as a tennis court, is another drawback. According to Hurd, I.B.M. is considering the development of a machine exclusively intended for translation. However, this cannot be accomplished until the Georgetown language specialists have elaborated additional instructions and specifications based on the experience that has been gained in the first phase of the joint project.

The time is still distant when it will be possible to insert a Russian scientific book into a translating machine and to receive from it an acceptable translation. It is highly doubtful that any machine could ever be devised that is capable of performing satisfactory translations of works of fiction or writings in which fine shades of meaning and subjective interpretations are involved. The translation of such a work as Milton's *Paradise Lost* or Tolstoy's *War and Peace* is in itself a creative act. Nor would mechanical devices ever eliminate the need for professional human translators. On the contrary, the latter would be freed from dull, routine hackwork and could devote themselves to the translation of works of literary and artistic merit that are more challenging in nature.

Neil MacDonald, describing the Georgetown-I.B.M. project in his article "Language translation by machine," which was published in the February 1954 issue of *Computers and Automation*, pointed out that the search for the solution of the translation problem brought to light many new facts that will tend to bridge the gap between the humanities and science. For example, it was found that the formulation of the logic required to convert word meanings properly, even in a small segment of two languages, necessitated as many instructions to the computer as are required to simulate the flight of a guided missile. He predicted that in the future

"Linguists will be able to study a language in the way that a physicist studies material in physics, with very few human prejudices and preconceptions, because the language has to be reduced to its operational characteristics in order to be handled electronically." All this suggests that a new discipline may emerge in which science and linguistics combine to solve international problems of human communication.

It may not be too visionary to suggest that with the perfecting of mechanical translation, significant writings of one land will be made available to interested readers in other countries shortly after they emerge from the presses. Thus, underdeveloped areas of the globe could receive the benefits of advanced science, technology, and knowledge at a rate impossible today. The general problem of the lag in the translation of key works from one language to another will certainly be remedied proportionally as machine translation becomes better developed.

Oceanographic Instrumentation

Allyn C. Vine

Oceanography as a science is still small enough so that physicists, biologists, chemists, geologists, and others who concentrate on the marine aspects of the profession are usually called oceanographers, particularly if they go to sea. Because it is a borderline field, the instrument requirements are as diverse as the problems; and because work on a ship is so different from work in a conventional laboratory, the instruments often develop along unconventional lines. In a short paper it is impractical to go into detail, or even to give fair coverage to all oceanographic instruments. Instead, I shall emphasize oceanographic problems, techniques, and instrument development, of which I have reasonable knowledge.

Sverdrup, Fleming, and Johnson have covered instruments in use up to 1940 in considerable detail (*1*). In 1952, the National Research Council and the Office of Naval Research sponsored a 3-day symposium on oceanographic instrumentation (*2*) that covered the present field of oceanographic instrumentation. Since each of the 12 papers had several discussants, the instrument problems were considered from different points of view, and much of the prevalent philosophy behind instrument development emerged in printed form. From the numerous references in these two sources, one can get fairly complete and up-to-date information.

Perhaps a brief description of some of the more significant characteristics of the ocean from the standpoint of a research worker or designer of instruments would be helpful. The fact that the ocean covers 70 percent of the earth is well known, but its division into surprisingly well-defined areas of continental shelves, oceanic basins, and deep trenches, somewhat comparable to the plains, plateaus, and mountain ranges on land, is less well known. In actual practice, this means that oceanographic instruments that are sensitive to, or dependent on, pressure are usually built and used for one of the following maximum depths: (i) 10 meters for har-

Mr. Vine is on the staff of the Woods Hole Oceanographic Institution, Woods Hole, Mass. This paper is a condensation of a discussion entitled "Oceanographic instrumentation" that was given at the AAAS Gordon Research Conference on Instrumentation at Colby Junior College on 28 July 1955.

bors and coastlines and for wave measurements, (ii) 200 meters for the continental shelf and the wind-stirred layer, (iii) 6000 meters for most of the open ocean, and (iv) 10,000 meters for the deep trenches.

Thus, oceanographic ships carry 5 to 6 miles of steel cable on their winches, and most deep-sea instrumentation must operate at water pressures of 600 kilograms per square centimeter (8500 pounds per square inch). In deep water the weight of the wire comes so close to the strength of the cable that tapered cables are often required for the great depths. Studying the depths or the bottom of the ocean can, with some justification, be compared to studying the continents from a balloon or aircraft at night at a height of 2 miles.

Water temperatures in the ocean vary from about $-1°C$ to about 30°C. The salinity can vary from nearly 40 parts per 1000 in the Red Sea to nearly fresh off the mouth of the Amazon. However, in the open sea the salinity seldom varies more than 2 parts from 35 parts per 1000.

Physically, the ocean seems homogeneous only to those who do not investigate it closely. Patches, streaks, and transients keep appearing as detailed observations are made. Biologically, many fish are in schools, and plankton concentration varies with depth and location. Observations made within a given similar area or time often must be made very precisely. Investigations aimed at studying the transition zones must be more numerous and emphasize qualitative features.

Research Vessel

Perhaps the most important instrument of all is the research vessel itself. Away from the dock it becomes not only a laboratory but a home and a way of life. The type of problem tackled and the quantity and precision of data obtained are determined to a large extent by the ability of the ship to go somewhere and get a job done, particularly in adverse weather. Shipboard research quickly convinces one of the importance of teamwork, and being considered a good shipmate is high praise. Equipment breakdowns at sea without adequate repair facilities bring out or show the lack of resourcefulness. Laboratory space is often cramped and inefficient. Yet a good research vessel has an undeniable laboratory atmosphere about it, because it represents our most effective large-scale contact with the ocean. Although both research ships and land-based laboratories are required in oceanography, the question of which should be regarded as the service facility for the other is debatable.

An efficient vessel is so important in oceanography that much consideration has been given recently to the design of a truly modern research vessel with increased maneuverability, larger and more convenient laboratory space, relative freedom from roll, and greater versatility. There has been a steady output of new laboratories, accelerating machines, and so forth, for research on land, but there has been no equivalent, sustained emphasis or building program to develop more versatile and capable research vessels for the study of the ocean. A research vessel is as specialized as a yacht, merchantman, or a warship, and converting one to the other can give only a partially adequate vessel.

Aircraft are being used more and more in oceanography and offer great possibilities for observation and the collection of data. It seems almost certain that the airplane will be used in direct proportion to the number of good oceanographic instruments designed for aircraft use.

The wider thinking and use of buoys to supplement ship or aircraft in the collection of data are also broadening the field of techniques and desirable instrumentation. A ship can plant or herd quite a number of buoys and thus increase its area of coverage. Buoys that float even at the bottom of the ocean have also been used to replace wires or cables and can carry instruments down to and back from the deepest parts of the ocean. This technique permits deep-water research to be done from a ship without a winch and also permits the equipment to stay on the bottom for a considerable length of time.

Temperature and Salinity Measurements

Because of the relative ease in measuring temperature in comparison with measuring salinity, density, or current, temperature has remained important, not only as an end in itself, but also as an indicator of other changes. It is presumed that temperature measurements will continue to be one of the most powerful and versatile ways to figure out our oceanographic puzzle.

During the years, we have gradually accumulated enough temperature measurements to obtain a rough over-all picture of the northern Atlantic and Pacific that is reasonably descriptive for large-scale phenomena. We are unable, however, to describe in a detailed way how thermal exchanges take place or accurately to predict small-scale oceanographic features.

Most of the water in the ocean is nearly isothermal and, at most, only a few degrees above freezing. However, except for the polar regions, in the winter the upper few hundred meters of the water column is warmed, and the result is a thermocline with a consequent density gradient that tends to isolate surface water from deep water. The high degree of vertical stability in the ocean is of great importance and is intimately tied up with the circulation of the ocean. The temperature gradients of the upper 100 or 200 meters of water may change with the seasons. If gradients are present at greater depths, they are referred to as the permanent thermocline.

Near the surface, large temperature changes can occur in a small depth difference, for example, as much as 10°C in 10 meters. At depth, the situation is reversed, and the temperature change may be as little as 0.1°C in 1000 meters. These important facts must be considered before one starts to build an all-purpose thermometer.

The Richter reversing thermometer is a mercury thermometer, which was developed in the 19th century, that, when upended, preserves the temperature reading at the moment of reversal to within about 0.01°C. This thermometer is mounted on a Nansen sampling bottle of about 1-liter capacity that closes off a sample of water when it is upended. From the sample the oxygen or salinity content of the water can be determined. A suitably spaced series of bottles and thermometers are placed on the wire and are tripped by an ingenious series of messengers that slide down the wire. The thermometers are usually used in pairs. The protected types are inside a pressure-proof glass case and read the true temperature of the water. The unprotected ones have the slightly compressible glass mercury bulb exposed to sea pressure; they read high by about 1°C per 100 meters of depth. This pressure coefficient of temperature thus furnishes a precise depth gage. The Nansen bottle-reversing thermometer combination has many limitations, but it is such a trouble-free and accurate device that it will surely be in use for a long time.

The bathythermograph, designed and improved just before World War II, was a significant step in making observations from a ship underway, and as a result there are several hundred thousand continuous temperature-depth traces for the top 50 to 250 meters over much of the ocean. The bathythermograph (BT) is a small, commercially available, torpedo-shaped instrument, with its mechanism exposed to sea water, that records on a smoked microscope slide. The speed of thermal response is only 0.8 seconds for a 90-percent response, and the precision is good to about 2 percent in depth and 0.1°C in temperature, depending somewhat on the instrument, the operator, and the usage. In operation, it is dropped

overboard and the 3/32-inch steel cable is paid out faster than the ship is moving. When depth is reached, the operator stops the winch, the BT rises nearly to the surface, and the operator then hoists the BT back to the ship and aboard.

A more recent instrument, the STD, continuously measures the temperature, electric conductivity, and depth and automatically computes the salinity of the water from the temperature-conductivity-salinity relationships and records temperature, salinity, and depth. This instrument has been of value in studying inshore and estuarine waters, but it needs another order of precision to be used on most offshore problems where changes tend to be smaller. The fact that the STD continuously computes and records a desired variable makes it a prototype instrument of unusual interest.

The study of thermal microstructure and the vertical distribution of temperature in the sediments under the bottom are new and interesting fields that are beginning to receive attention. Infrared measurements of surface temperatures from aircraft show great promise of delineating gross features, such as the edge of the Gulf Stream, with a detail and speed that was not possible before.

Current Measurements

The circulation of the ocean is sufficiently complex and interesting to bring out a full array of ideas and instruments. Many current measurements are made as they were hundreds of years ago (and as the jet stream was recently discovered in the upper atmosphere) by recording errors in dead reckoning. This amounts to the navigator noting that his ship did not go where he thought it was going. If good navigation or loran is available, this ship-set method is not as crude as one might suppose.

The drift method has been elaborated by setting out and following drifting buoys that transmit radio signals that can be homed on from the land or a ship. The motion of water far below the surface has been observed by following surface buoys that are secured by thin piano wire to deep-sea anchors made of aviator's parachutes and located at the depths of interest. Where offshore navigation is inadequate, buoys have been anchored to the bottom by piano wire even in several miles of water and have served as fixed references for making local current measurements or local bathymetric surveys.

Many propeller-type current meters have been built and several types are in frequent use. Perhaps the most novel current meter has been the GEK (Geomagnetic Electro Kinetograph), which, in effect, measures with a potentiometer the difference in voltage induced in a wire towed behind a ship and the voltage induced in the ocean as it flows through the earth's vertical magnetic field. The voltage difference is of the order of 1 millivolt per knot of current for spacing of 100 meters between the silver-silver chloride electrodes and is independent of the ship's velocity. The instrument is also known as the Jog Log, because the navigator is asked to make frequent three-sided rectangular jogs from the ship's base course in order to obtain two components of the current and to redetermine the electric zero of the instrument. In spite of certain theoretical and practical limitations, particularly in shoal water, the GEK has quickly become a basic and widely used oceanographic instrument.

Acoustic Measurements

Because the ocean is so much more transparent to acoustic waves than to electromagnetic waves, sound is a principal means of studying the ocean with both active and passive sonar gear. The echo sounder is the most widely used acoustic instrument. At sea it has been used successfully in studying the daily vertical migration of organisms as well as the depth of the water, and in shallow water it sometimes shows the depths of thin sediments. Geophysical seismic exploration techniques have been used at sea for nearly two decades and have produced quantitative and exciting data about geologic structures under the ocean. Explosives are a favorite sound source for acoustics work, because they are such convenient high-energy, broad-band sources. The use of broad-band sources and frequency analysis on the signal often gives clues regarding the creature or geologic layer being studied.

One of the most exciting new uses for sound is in telemetering scientific data to the surface as it is being taken. Not only does this permit more data to be taken, but it also permits the scientists to study changes and transients in a less haphazard and survey manner. Acoustic beacons also provide a way of locating or following surface or subsurface buoys or of using a bottomed beacon as a local fixed point for a bathymetric survey.

Underwater Photography

In harbors the visibility may drop to a fraction of a meter. The visibility in the open sea is comparable to a thick fog and may range between 10 and 80 meters. Good pictures can be taken at about one-third to one-half of this distance. Although this limits photography or vision, it permits clear underwater pictures to be taken over a larger area than can usually be illuminated with artificial light. Numerous bottom photographs have been taken at depths up to several thousand meters. The problems of underwater photography are not primarily optical ones; rather, they are the mechanics and techniques required to handle the gear and to keep the camera at the right range from and pointed toward the target. The lens focus is set at three-fourths of the distance that it would be in air, and the amount of illumination is increased. Flashbulbs and electronic light sources have both been used with success. The easiest photographic subject to get is the bottom, because the picture can be taken in a downward direction, with the distance established when a weight on a known length of string touches bottom.

Underwater television is in its infancy, but it should do much to increase our knowledge of the ocean bottom and marine life at shallow depths.

Bathymetry

The development of piano wire in the 19th century permitted, for the first time, the making of a reasonable number of soundings in the open ocean. The invention in this century of the echo sounder, which electrically times and records a sound wave going to the bottom and back, has permitted continuous depth profiles to be made from ships underway. The great submerged ranges and deep trenches showed up very quickly, but only in the last few years have echo sounders been developed to give depths to, say, 1 meter out of 5000. This type of precision has been obtained by making the timing circuit and recorder precise to better than 1 millisecond, as in facsimile recorders that are used for transmitting weather maps. As usual in science, newer and more accurate data continue to open up new problems. The added precision is never a hindrance, and often it is essential in order to tell whether the ocean bottom is really flat, like parts of Kansas, or rolling, like parts of new England. In addition, it has shown that little ridges or valleys exist in broad plain areas, which might otherwise have been thought to be instrumental error. The finite width of the acoustic beam below the ship has some advantages and some disadvantages. The recording shows the closest bottom, whether it is exactly under the ship or not. Because of this, the records sometimes need greater interpretation, but also there is more there to interpret. The full potentialities of the echo sounder and its many variations have not yet been fully recognized or widely exploited.

Pressure Vessels and Materials

It is often possible to make instruments that do not need pressure-proof cases. A surprising number of commercial items, such as small photoflashbulbs, work well under pressure. Some subminiature vacuum tubes and electronic parts will stand depths of thousands of meters when they are housed in an oil-filled flexible container. Automobile and flashlight batteries operate satisfactorily at the bottom of the ocean if external insulation is provided. Smoked glass, waxed paper, or soft metal plates are water resistant and can be scribed with very light pressures.

Glass, bronze, stainless steel, aluminum, plastics, and ordinary steel have all been used successfully as pressure vessels, with the choice being dependent on weight, handling problems, availability, and cost. For the thicker instrument cases of cylindrical form, one can consider the ratio of the wall thickness to the radius of the tube to be the same as the ratio of the external pressure to the desired maximum working stress of the material. It is also possible to make pressure vessels of glass or aluminum that can go to a depth of several miles and still be light enough to be buoyant. Corrosion problems can be minimized by proper choice of materials, design clearances, and "elbow grease."

Oddly enough, oceanographers are seldom bothered more by leaks at great depth than they are at shallow depths. This is because, when designing for great depths, they usually take pains to design seals properly. Modern electronic equipment is amazingly trouble free if given reasonable care.

Conclusion

Many instrument problems, such as navigation, the collection of bottom samples, the measurement of gravity at sea, the design of unattended instruments, towed electric cables, marine meteorology, marine biology, and the study of radioactive waste disposal, are just as interesting and essential as those to which space has been devoted. Also, it has not been possible to discuss here the many oceanographic instruments in the shore laboratory that are needed to supplement seagoing work. This omission is only partly excusable on the grounds that they tend to be more like conventional instruments.

I hope that this article (*3*) gives some idea of the scope of oceanographic instruments. It should be apparent that most instrumentation should be simple, rugged, and reliable. However, for exploratory work, serious scientists use the best instruments available. In most cases, the designer has to be shipmates with his creation before it can be called an instrument. The designer and user must work as a team, because simple measurements and precise thinking usually result in a greater scientific product than precise measurements and simple thinking. Rather than dwell on the relative merits of theory versus measurement, I hope that instrument designers, experimentalists, and theoreticians will each do their work aggressively and well.

References and Notes

1. H. U. Sverdrup, R. H. Fleming, N. W. Johnson, *The Oceans* (Prentice-Hall, New York, 1942).
2. *Natl. Research Council Natl. Acad. Sci. (U.S.) Publ. No. 309, Oceanographic Instrumentation.*
3. Contribution No. 806 from the Woods Hole Oceanographic Institution.

Determination of Sources of Particulate Atmospheric Carbon

George D. Clayton, James R. Arnold, Frank A. Patty

The Los Angeles smog is probably the most publicized of any air pollution problem. Millions of dollars have been spent, and additional millions are presently being expended in an effort to determine the causative agent or agents that produce eye irritation, reduced visibility, rubber cracking, and plant damage. The attack on the problem by the multitude of agencies and organizations may be classified into two broad categories: (i) determination of the contaminant or contaminants causing the smog; and (ii) determination of the sources of pollution.

There is substantial evidence that an irradiated gaseous mixture of hydrocarbons and oxides of nitrogen produce the strong oxidizing property found in the Los Angeles basin air. It has been proved in experiments that a laboratory mixture having similar oxidizing properties to that found in the Los Angeles air (reported as ozone, with concentrations reported as high as 1.0 part per million) can cause rubber cracking, eye irritation, and plant damage.

The sources of contaminants have been extensively studied, and it is reported that the largest quantity of air contaminants in Los Angeles originate from combustion processes. It is estimated that approximately half of the pollution is created by auto exhausts and backyard incineration. According to calculations based on the consumption of gasoline, approximately 1000 tons of hydrocarbons, 300 tons of organic acids and aldehydes, and oxides of nitrogen and sulfur are emitted from exhaust pipes daily.

Larson (*1*) states that, on the basis of 3 pounds of rubbish per person per day, commercial and household rubbish amounts to about 6000 tons each day, with most of this material being disposed of by backyard incineration. Industrial rubbish, amounting to 3000 tons per day, is handled either by industrial incineration or by "cut and fill" operation.

Although extensive work has been done in studying the effluent of single sources of pollution, it has been understandably difficult to relate these findings to what is found in the general atmosphere.

It is well known that particulate matter in the atmosphere influences visibility. Photographs taken while backyard incineration was in progress show the effect this source has on reduced visibility in Los Angeles. The purpose of our investigation was to study the origin of the carbon constituent of atmospheric particulate matter.

There exists an unequivocal method for distinguishing between carbonaceous

Mr. Clayton is a consulting engineer in air pollution and industrial health with offices at 14125 Prevost, Detroit, Mich. Dr. Arnold is an assistant professor at the Institute of Nuclear Studies, University of Chicago. Mr. Patty is director of the Industrial Hygiene Department, Research Laboratories Division of General Motors Corporation.

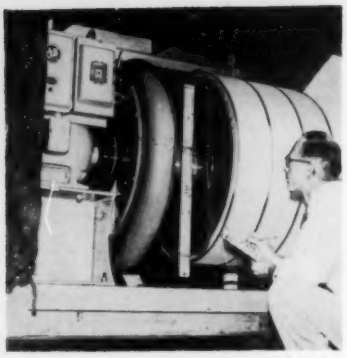


Fig. 1. Sampler.

material arising from biological sources and that from fossil fuels such as coal, oil, and natural gas. This method is based on the carbon-14 content of the living materials (*2*). It has been shown that all biological materials contain an almost exactly constant proportion of radioactive carbon-14 relative to their normal carbon. The half-life of carbon-14 (about 5600 years) insures that no activity remains in the carbon of fossil fuels. Materials of ages from 1000 to perhaps 40,000 years contain intermediate but detectable amounts of carbon-14 activity. Since the materials contaminating the atmosphere above a city are either contemporary—that is, they contain the same amount of activity as all other living materials—or inert, a measurement of the carbon-14 activity of such a sample will indicate the fraction attributable to biological sources of all kinds. These might include carbon originating from trash burning, pollen, forest fires, and other sources.

Instrument. To determine the carbon content of the particulate matter in Los Angeles atmosphere during a period of smog, a special sampler was constructed (Fig. 1). The fan is American Blower Size 6 Type F 28-inch wheel driven by a 25-horsepower, 220-volt motor. The filter cage or holder is 38 inches in diameter with a screened surface 2 feet wide and 10 feet in circumference. An inner screen was made of ½-inch mesh hardware cloth covered with 16-mesh bronze screen. This filter cage was equipped with four quick acting bands to hold three strips of 8-inch filter in position over the screen. The outlet side of the fan was equipped with a 3⅜-inch orifice plate to hold the amperage of the motor down to within the permissible load. The inlet side of the fan, between fan and filter, was equipped with a 5-inch diameter plate orifice and manometer for estimating air flow rates. One water manometer indicates the pressure across the orifice plate and another indicates the total suction on the filter.

The sampler was calibrated by means of a pitot tube. It was found that it collected an average of about 1000 cubic feet per minute.

The collecting medium was Hurlbut filter No. 935 with a distortion point of 611°C; 99.95 percent efficient in 0.3 microns dioctyl phthate (DOP) smoke particles; resistance, 110 millimeters of water at 28 feet per minute, with glass fibers 0.5 to 0.75 micron in diameter. The material used was purchased from the Mine Safety Appliance Company.

Measurement procedures. The carbon-14 assay of the samples was measured by a liquid scintillation method (*3*). This involved the conversion of the sample carbon into liquid hydrocarbon suitable for measurement. The procedure is briefly the following. The sample is burned in a stream of oxygen, and the resulting carbon dioxide is collected in ammonium hydroxide solution. It is then precipitated as strontium carbonate, which is converted to the carbide by reaction with magnesium metal. This is then hydrolyzed to give acetylene, which is polymerized in the presence of cuprous chloride to give unsaturated C_6 and C_8 hydrocarbons. These are then hydrogenated to give a product that is chiefly hexane and octane. This chemical procedure was adapted, with modifications, from the work of Suess (*4*) and Nieuwland (*5*). The carbon content of the liquid is determined by a combustion analysis, and the carbon-13 to carbon-12 ratio is determined in order to correct for hydrocarbon fractionation in nature or in the laboratory.

The method of measuring the carbon-14 content of the sample has been previously described (*3*). A description of a number of minor improvements is in preparation. Because of the small size of the samples involved, a cell of 10-milliliter capacity was used. With a sample of approximately 2 grams of liquid hydrocarbon, we were able to measure the percentage of living carbon to an accuracy of ±1.5 percent in 24 hours of counting.

Table 1. Carbon analysis of air samples

Sample	Air vol. (10^6 cubic feet)	Total weight (grams)	Total carbon content (grams)	Contemporary carbon (percentage)
Detroit I	6.1	35	6	†
Detroit II	3.2	18*	3*	12.6 ± 3.0
Los Angeles I	6.25	31	6	25.7 ± 1.6
Los Angeles II	8.5	41.7	8	23.2 ± 1.4

* Approximate value—filter torn. † Sample lost in processing.

Table 2. Beryllium-7 analysis of air samples. Units are disintegrations of beryllium-7 per minute, per thousand cubic feet at the time of collection

Sample	Activity zero days
Detroit I	4.5
Detroit II	1.0
Los Angeles I	1.3
Los Angeles II	2.4

Sampling period and locations. Samples were collected at one location in Detroit and one location in Los Angeles. It may be noted that the sampler operated from 4 to 6 days for the collection of each sample. The selection of sampling sites and the collection of samples were under the supervision of Vincent J. Castrop, Industrial Hygiene Department, Research Laboratories Division, General Motors Corporation. Four samples were collected, as follows: (i) *Detroit I,* 3 Sept. 1954 at 2:25 P.M. continuously until 7 Sept. 1954 at 8:15 A.M., from a location on the roof of the 11-story General Motors Research Building; (ii) *Detroit II,* 7 Sept. 1954 at 9:35 A.M., until 2:20 P.M. 13 Sept. 1954, intermittently while calibrating for approximately 2 hours, 14 Sept. 1954 at 8:45 A.M. continuously until 16 Sept. 1954 at 8:45 A.M. from the same location as *Detroit I*; (iii) *Los Angeles I,* 14 Oct. 1954, ½ hour, 15 Oct. 1954 at 8:30 A.M. continuously until 19 Oct. 1954 at 4:20 P.M. from a location in Brookside Park (about ½ mile south of the Rose Bowl); (iv) *Los Angeles II,* 19 Oct. 1954 at 11:50 P.M. continuously until 25 Oct. 1954 at 1:30 P.M. from the same location and filter area as *Los Angeles I.*

Weather conditions. In Detroit, haze, smoke, and fog were moderately light and present during less than 20 percent of the sampling period. There were winds of 5 to 15 miles per hour and brief showers. Visibility ranged from 3 to 14 miles and for most of the period was above 10 miles. In Los Angeles, both samples were taken during a period of fog and severe haze. Complaints of eye smarting were frequent during daylight hours.

Results of study. Table 1 presents the results of the investigation. It is of interest to note that the total carbon content of each sample was only about 20

percent of the total weight. Thus, carbon is a minor constituent of the total particulate load found in the Los Angeles and Detroit atmospheres.

Beryllium-7, with a half-life of 53 days, has recently been found to be produced by cosmic rays in the atmosphere (*6*). We have analyzed the present samples for beryllium-7 content. There is as yet an insufficient number of comparison samples to make the results highly meaningful. They are, however, presented in Table 2. It is possible that, when sufficient results have been obtained, a useful measure of the rate of subsidence of the atmosphere in the Los Angeles area can be obtained using this isotope.

The sensitive counting techniques used in this study may be applied to tracer experiments as well as to natural activities. Simple calculation shows that it would be quite practical to introduce sufficient tracer, either carbon-14 or some other isotope, into any suspected source of contamination in an area the size of the Los Angeles basin, in order to determine the percentage of contamination arising from this particular source. For example, the entire gasoline supply could be tagged at an adequate level for a period of 30 days, in order to determine the contribution of automobile exhausts to the atmospheric carbon. Since the level of radioactivity in the consumer product can be well below that of the human body, no safety hazard to the public is involved.

The tests conducted proved the effectiveness of the technique used and reveal that this procedure is a useful tool in determining whether or not the atmospheric carbon is newly formed, as from rubbish burning, or is aged, as from petroleum, gas, and coal sources.

References

1. G. P. Larson, *Problems of Rubbish Disposal As Affecting Air Pollution, Los Angeles*, Report No. 3, Conference on Incineration, Rubbish Disposal and Air Pollution (Air Pollution Foundation, Los Angeles, Calif., 1955).
2. W. F. Libby, *Radiocarbon Dating* (Univ. of Chicago Press, Chicago, ed. 2, 1955).
3. J. R. Arnold, *Science* **119**, 155 (1954).
4. H. Suess, *Science* **120**, 5 (1954).
5. J. A. Nieuwland and R. R. Vogt, *The Chemistry of Acetylene* (Reinhold, New York, 1954).
6. J. R. Arnold, *Science* **121**, 451 (1955).

I. M. Cline, Expert on Hurricanes

Isaac Monroe Cline, who achieved an international reputation as a weatherman, died in New Orleans, Louisiana, on 3 August 1955 at the age of 94. The career of Cline, who rose from plow boy to principal meteorologist of the U.S. Weather Bureau, with medicine and art on the side, distinguished him as one of New Orleans' truly remarkable men. His professional career in meteorology embraced 53 years of service with the Weather Bureau during which time the weather service developed from a unit in the Signal Corps of the Army to a separate bureau in the Department of Agriculture.

Cline was born in Monroe county, Tennessee, on 13 October 1861. He received his B.A. degree from Hiwassee college in 1882 and was awarded a medical degree from the University of Arkansas in 1885, while he was working as an observer for the weather service in Little Rock, Arkansas. He served as observer at Fort Concho and Abilene, Texas. In 1889 he was appointed as section director at Galveston, and in 1891 the weather service was transferred to the Department of Agriculture. During this period he carried out research and made significant contributions in the field of medical climatology and a study of the hot summer winds on the Great Plains. He received his Ph.D. degree from Texas Christian University while he was at Galveston.

The Galveston hurricane of 8 September 1900 established Cline as an expert on tropical hurricanes. Notwithstanding the fact that 6000 residents of Galveston had been hurled to death in a few hours by the winds and tides, the warnings that were sent out by Cline are said to have saved tens of thousands of lives along the coast. Despite his heroic attempts at rescue, Cline suffered personal tragedy in the loss of his wife, Cora May Ballew, during this disaster. As a result of his experiences during this hurricane Cline resolved to devote his life to research and study of this natural phenomenon.

In 1901 he was transferred as official-in-charge of the southern forecast district in New Orleans, Louisiana. It was during his 34 years at New Orleans that Cline rose to international fame in the field of hurricane and flood forecasting. His superb forecasts of the Mississippi River floods of 1903 and 1927, as well as the tropical hurricanes at New Orleans, 29 September 1915 and the Texas Gulf Coast, 21–22 June 1921, are accorded a high place in the annals of Weather Bureau history. His intimate knowledge and study of tropical hurricanes resulted in the publication of his book *Tropical Cyclones* in 1926.

During his years in New Orleans, Cline found time to pursue his hobby of art collecting. As a result, some of the finest portraits painted by American artists were rescued from oblivion, preserved from destruction, and now hang in the National Gallery of Art in Washington. He became an expert in the restoration of masterpieces of portraiture.

In 1934 Cline retired from active service with the Weather Bureau. Tulane University awarded him an honorary D.Sc. degree for his achievements in the science of meteorology and his contribution to the cause of humanity by the saving of life and property during floods and tropical hurricanes.

After retirement he operated an antique shop in New Orleans and became affectionately known as the "dean" of the famous French Quarter, the habitat of writers and artists and the cultural center of the city's activities. Ten years later he published *Storms, Floods and Sunshine*, an entertaining autobiography, which has undergone several revisions.

The keynote of his life was the proper utilization of time, particularly the efficient use of recreation time. His life was an excellent example of it.

He was a member of numerous scientific societies and congresses. He served as president of the American Meteorological society in 1934–35 and the New Orleans Academy of Sciences in 1935–36. In the words of former President Herbert C. Hoover, his work "has been more than the mere routine interpretation of technical data. It required judgment and discretion, which amounted to genius. He has been an honor to the Weather Bureau."

JOSEPH T. HOGAN

New Orleans, Louisiana

News of Science

First U.S. Trade Fair of the Atomic Industry

Approximately 70 industrial firms and organizations exhibited various types of materials, equipment, and instruments suitable for use in constructive applications of atomic energy at the first U.S. Trade Fair of the Atomic Industry in Washington, D.C., 27–30 Sept. The fair was held at the Sheraton-Park Hotel in conjunction with the annual Forum on Commercial and International Developments in Atomic Energy sponsored by the Atomic Industrial Forum, Inc.

Products displayed included the following: (i) metals, alloys, and compounds capable of withstanding the effects of high-temperature, high-pressure, corrosive atmospheres; (ii) reactor and power-plant components fabricated from these materials; (iii) materials for shielding against radiation and devices for remote handling and observation of radioactive materials; (iv) basic instrumentation for the detection, measurement, and analysis of radioactivity, as well as instruments for use in x-ray therapy and other medical applications of atomic energy, radiation sterilization, processing, radiography, and fundamental research; (v) reactor control mechanisms and panels; and (vi) models of several research reactors and nuclear power plants.

Metals, alloys, and compounds suitable for use in the fabrication of pipe, fittings, pumps, valves, heat exchangers, reactor vessels, fuel elements and other internal components of nuclear reactors, and waste storage tanks were displayed by several companies. Brush Beryllium Company: fabricated shapes — block, rod, sheet, foil, and tubing—of beryllium; beryllium oxide and beryllium alloys. Carborundum Company: properties of zirconium and its alloys; reactor-grade zirconium and alloys in sponge, ingot, and fabricated shapes. International Nickel Company: high-temperature application of nickel alloys; Inco-Rod A for welding dissimilar alloys. Lukens Steel Company: clad steel for ore-processing equipment, heat exchangers, and acid and waste storage tanks. Metals and Controls Corporation: ingots and shapes of aluminum-uranium alloy, thorium, and zirconium for fabrication of fuel elements and fuel plates. National Carbon Company: high-purity graphite for use as a moderator, reflector, and shield; molds and crucibles used in reprocessing metals. National Lead Company: zirconium, titanium, and other metals. Norton Company: boron compounds; refractories; and oxide, boride, carbide, and nitride materials in granular and powdered form. Republic Steel Corporation: corrosion resistance, thermal resistance, and fabrication qualities of stainless steel and titanium. Vitro Corporation of America: mining, milling, processing, and refining of uranium.

Displays or descriptions of large numbers of reactor components and power plant components were presented by more than 25 companies. In general, only the smaller components such as high-pressure pipe, valves, and fittings; pumps and mechanical seals for liquid sodium and other corrosive liquids; fuel elements; and control rods and control-rod drive mechanisms were actually on display.

Among them were Chempump Corporation's seal-less centrifugal pump; Metals and Controls Corporation's fuel elements, including the rod, tube, and flat-plate types; Robertshaw-Fulton Controls Company's packless valve; and Westinghouse Electric Corporation's hermetically-sealed motor pump for pressures up to 2500 pounds per square inch and temperatures up to 650°F.

Babcock and Wilcox Company displayed a section of the core of the pressurized-water thorium-uranium converter reactor that will be used in Consolidated Edison Company's nuclear-powered electric-generating station at Indian Point, N.Y. The core is made up of replaceable, square-cross-section fuel elements, each of which contains alternate basic fuel plates of a uranium-Zircaloy matrix clad with Zircaloy and fertile plates of thorium clad in Zircaloy. The moderator and coolant, ordinary water, flows through the channels formed by the alternate fuel and fertile plates.

Other components exhibited or described included reactor vessels, steam generators and superheaters, heat exchangers, and gas and steam turbines. Among the turbines described were some that can be operated by steam direct from a reactor; their use would eliminate the need for a heat exchanger in the steam system.

Corning Glass Works displayed 6-foot-thick radiation windows of glass composition that will not darken under intensive radiation. Other shielding devices included biological research enclosures; hoods; and shipping containers, transfer casks, and vaults made of lead and other materials. National Lead Company showed samples of concrete to which barites or magnetite had been added to increase the density. Remote handling equipment included Central Research Laboratories' Master-Slave Manipulator and General Mills' mechanical arm.

Approximately 25 companies had numerous instruments on display. Some companies emphasized survey and prospecting instruments, others emphasized instruments for research, and still others instruments for industrial use. Counters, scalers, rate meters, thickness gages, liquid-level gages, monitoring instruments, density gages, and radiation sources for calibration were among those included. Central Scientific Company showed a meter that utilizes the absorption of beta rays from a strontium-90 source to measure the percentage of hydrogen in liquid hydrocarbons. M. W. Kellogg Company gave radiography demonstrations using radioisotopes in the Kel-Ray projector.

An operating reactor simulator, including rod-drive mechanism and reactor control panel, was displayed by the Minneapolis-Honeywell Regulator Company. It included recorders and amplifiers for the start-up channel, safety channel, log N, and the period channel. The "scram" button, which broke a magnetic circuit and released the control rod, attracted the spectators. Westinghouse Electric Corporation exhibited the Mark II nuclear reactor control assembly.

Models of several nuclear research and power reactors were on display, including the following electric-power-generating reactor plants. Allis Chalmers Manufacturing Company: nuclear electric power plant under construction at Argonne National Laboratory under the AEC's 5-year reactor development program; completion is scheduled for 1956. Atomic Power Development Associates: model and explanatory material concerning a liquid-metal-cooled fast neutron breeder reactor power plant that will operate a 100,000-kilowatt generator. Consolidated Edison Company: model of proposed nuclear power station with a capacity of 250,000 kilowatts; this plant will use a heat exchanger to keep the reactor-coolant water separated from the steam that operates the turbine. An oil-fired superheater will be used.

General Electric Company: model of a dual cycle boiling water reactor to be used to power a 180,000-kilowatt plant that the Commonwealth Edison Company, a member of the Nuclear Power Group, proposes to build at the confluence of the Kankakee and Des Plaines rivers 47 miles south of Chicago, Ill. Newport News Shipbuilding and Drydock Company: model of homogeneous reactor developed by the Union Carbide Nuclear Company; model of a Mariner class merchant vessel showing possible utilization of nuclear power for propulsion.

NBS Velocimeter

The National Bureau of Standards has developed an instrument, a velocimeter, that automatically measures the speed of sound in the sea to depths as great as 300 feet and plots the result as a function of depth or time. Martin Greenspan and C. E. Tschiegg of the bureau's Sound Laboratory designed and constructed the instrument under the sponsorship of the Office of Naval Research. Because of its high accuracy and almost instantaneous response, the velocimeter is expected to be a useful addition to underwater signaling and detecting apparatus; it should also prove to be a valuable research instrument in oceanography.

The speed of sound in large natural bodies of water varies from about 4600 to 5140 feet per second. These variations occur with changes in temperature and, to a lesser extent, with changes in water salinity. Sound velocity also increases about 1 foot per second for each 55-foot increase in depth. Several other factors, not all of which are well understood, influence the velocity of sound in the sea. In current practice an estimate of the sound velocity is calculated from the measured temperature and an assumed salinity. The NBS velocimeter, on the other hand, gives an almost instantaneous meter reading of the actual sound velocity.

The instrument consists essentially of a pair of piezoelectric transducers of polarized barium-calcium-lead titanate and a reflector mounted to form a sound path of fixed length. The sending transducer is connected to a pulse generator, and the receiving transducer provides the input for a high-gain pulse-shaping amplifier. The amplifier output retriggers the pulse generator, which then applies another pulse to the sender. The sender in turn produces in the water a sound pulse to actuate the receiver. Thus the system continually regenerates a sound pulse whose repetition rate depends on the time it takes the pulse to move through the water. Since the path length is fixed, the frequency depends only on the speed of sound through the water and on the circuit delays. Any variations in sound velocity are recorded as variations in the operating frequency of the velocimeter.

News Briefs

■ Cecil F. Powell of Great Britain, head of the Bristol University physics department and 1950 Nobel prize recipient, has just returned from a 4-day tour of Soviet nuclear plants. He reports that the 37,000-ton proton synchro-cyclotron on the Volga River is the biggest of its kind in the world. He also reports that Bruno Pontecorvo is working there.

Pontecorvo, born in Italy in 1913, was a naturalized Briton who became senior principal scientific officer at Harwell, a major British nuclear research center. He disappeared while on a holiday in Italy in 1950, then last March he held a press conference in Moscow. He is said to have become a Russian citizen in 1952.

During the recent meeting of the British Association for the Advancement of Science, Powell made known that he had received an invitation to go to Moscow to discuss collaboration in cosmic ray research between Great Britain and the Soviet Union. The proposal for this cooperation came from the Moscow Academy of Sciences.

Powell has expressed interest in the plan. He commented that although there has been a good deal of collaboration with American cosmic ray specialists, little is known of the Soviet work and an exchange of information would be invaluable. Powell, who has been the leader of Britain's study of cosmic rays, is particularly interested in gaining permission to undertake an expedition to the Soviet Arctic.

■ A high-frequency titrimeter for the chemical analysis of complex mixtures has been designed by Andrew Timnick of the Michigan State University chemistry department and Arthur H. Johnson, now with the Bauer and Black Company of Chicago. With the new device analyses can be made without introducing electrodes or electric probes into the solution being studied. The instrument operates in the 100-megacycle-per-second range. Analyses can be carried out on solutions of high concentrations.

■ An electronic instrument that will enable optical scientists to evaluate and grade the performance quality of lenses in objective mathematical terms has been developed experimentally by the Radio Corporation of America. The lens-tester resulted from initial research conducted by Otto H. Schade, R.C.A. engineer who has pioneered in the development of universal ratings and allied test equipment with which the picture quality of all picture-reproducing devices—lenses, motion picture film, TV cameras, and picture tubes—can be determined with scientific objectivity.

Heretofore, the performance quality of any given lens, with regard to sharpness, contrast, and gradation, has been determined solely by visual tests. The R.C.A. device will enable lens manufacturers and users to determine the response characteristics of a lens and compare them with mathematical optimums.

Major components of the lens-tester include a special test drum, a microscope, a multiplier phototube, and an oscilloscope. The test drum has nine groups of high-contrast black-and-white lines of different widths, ranging from 3 per inch for the coarse group to 200 per inch for the finest group. The black lines correspond to 3 to 200 TV lines per millimeter in the image.

To obtain the square wave flux response of a given lens, it is made to view the test drum, which is revolved by a synchronous motor. The lens is also rotated, about its transverse axis, to test its performance off axis. The lens image of the test drum is then scanned by the multiplier phototube through a narrow slit.

For a theoretically perfect lens, the contrast between black and white lines, as measured by the phototube, would be modified only by diffraction effects. With a practical lens, the contrast deteriorates as the line width decreases because of the combined effects of diffraction and aberrations. The line at which the contrast disappears represents zero square wave flux response for the given lens.

■ The surplus of women over men in Sweden dropped from 130 per 1000 in the middle of the 18th century to only 8 per 1000 by 1950 according to a recent publication issued by the Swedish Central Bureau of Statistics. The number of persons over 65 years of age has increased from 6 to 10 percent of the total, while that of persons below 15 has decreased from 33 to 23 percent of the population.

■ Findings that throw considerable light on the nature of the oxygen effect in modifying some of the effects of ionizing radiations on living systems are reported by H. Laser of the University of Cambridge in *Nature* (20 Aug.). The change produced in hemoglobin depended on its initial oxidized or reduced state, and was independent of the presence of oxygen. That is, irradiated hemoglobin becomes oxidized, whereas methemoglobin becomes reduced.

Like hemoglobin, ferrocytochrome becomes oxidized whether irradiated in air

or in nitrogen. Ferricytochrome becomes reduced when irradiated in nitrogen, but anomalously was not affected at all when irradiated in air at doses up to 35 kiloroentgens.

The catalytic activity of succinic oxidation by cytochrome *c* was reduced by only 15 percent after receiving 35 kiloroentgens in air. The same dose in nitrogen caused a 35 percent loss of activity, apparently because the initial reaction product undergoes a secondary and irreversible oxidation to a green pigment after oxygen is admitted.—B.G.

■ Some 99,000 gallons of drinkable water were produced and distributed by the Army's new mobile purifier during 9 days of emergency operation recently in flooded Stroudsburg, Pa. Developed by the Corps of Engineers Research and Development Laboratories, Fort Belvoir, Va., the truck-mounted unit is capable of purifying 3000 gallons of water an hour, 24 hours a day.

The unit, which is nearing standardization by the Army, is one of a group of purifiers that have resulted from years of basic and applied research at the laboratories. Other units include 1500 and 600-gallon-per-hour capacity mobile purifiers, and a semipermanent one capable of producing 10,000 gallons per hour.

■ An electronic instrument for the measurement of muscle strength was reported at the recent meeting of the American Congress of Physical Medicine and Rehabilitation by Willis C. Beasley of Children's Hospital, Washington, D.C. Currently, when muscle strength has been affected by neuromuscular diseases, such as poliomyelitis, the degree or amount of remaining strength is measured manually by a physician or physical therapist. Manual measurement, of necessity, must involve the subjective opinion or interpretation of the examiner.

Following ten years of study supported by the National Institutes of Health and the National Foundation for Infantile Paralysis, Beasley, a biophysicist, has developed a method of measuring muscle strength electronically.

Although an examiner using manual methods may obtain a relatively accurate measurement of the immediate muscle strength, the mechanical method is also able to determine the degree of lasting strength.

■ A calendar determinant, a 7½- by 10-inch device that, by means of slides, can display the calendar for any Gregorian month in a span of 400 years, has been invented by Osmund Robin of Croydon, England. The instrument's range could be extended indefinitely.

Development of the new calendar is reported in the August issue of the *Journal of the Horological Institute of America*, which comments that the invention is a "remarkable commentary on the inconsistencies of the Gregorian calendar, which requires so ingenious a device to enable one to determine a past or future date."

■ Identification of certain human-type bones in a gorilla and a chimpanzee is reported in the 24 Sept. issue of *Nature* by G. T. Ashley of the department of anatomy, University of Manchester, England. The bones, suprasternal ossicles, are located just above the breast bone. They are quite common in man, but until 1944 they had never been seen in primates other than man.

In that year Adolph Schultz of Johns Hopkins University reported finding them in two gibbons. They have not been reported in monkeys or orangutans. In man these small bones were at one time thought to represent rudiments of the furculum, or wishbone, of birds. Now they are thought to be rudiments of a bony structure of the primitive shoulder girdle.

Scientists in the News

HELEN SAWYER HOGG, associate professor at the University of Toronto, has been appointed program director for astronomy in the division of mathematical, physical, and engineering sciences of the National Science Foundation. She is on leave of absence from the university.

VERNON BRYSON is program director for genetic and developmental biology. Since 1943 he has been working as a geneticist at the Long Island Biological Association, Cold Spring Harbor, N.Y.

FRANK RICHARDSON, who is on leave from the University of Nevada, has been appointed visiting lecturer for the current academic year in the department of zoology of the University of Washington, Seattle.

In a ceremony that took place on 20 Sept. at the Southern Utilization Research Branch of the U.S. Department of Agriculture, New Orleans, La., Secretary of Agriculture Ezra T. Benson presented a Superior Service Award plaque to a group of scientists on the branch's staff. Members of the group were DOROTHY C. HEINZELMAN, RALPH W. PLANCK, FRANK G. DOLLEAR, FRANK C. PACK, and ROBERT T. O'CONNOR. The award was given to the group in recognition of its members' work in the development of new and highly improved methods of analysis that are of importance to research on new uses for fats and oils.

KENNER F. HERTFORD became manager of the Atomic Energy Commission's Santa Fe Operations Office on 1 Oct. He succeeded DONALD J. LEEHEY, who has resigned and plans to establish an engineering consultant's office in Seattle, Wash. Hertford retired from the U.S. Army Corps of Engineers on 31 July in order to accept the AEC appointment. Santa Fe Operations has field responsibility for the commission's program for the research, development, production, and testing of nuclear weapons.

T. GOLD, chief assistant to the Astronomer Royal, Royal Observatory, England, will deliver two lectures in the physics department of the University of Maryland on 25 and 26 Oct. He will discuss "Some aspects of the history of the earth" and " Field of a uniformly accelerated charge."

WILLIAM E. WRATHER, director of the Geological Survey, U.S. Department of the Interior, received the department's Distinguished Service Award on 21 Sept. Wrather first joined the Survey in 1907, working with a field party during the summer in Montana. Then he worked for a long period in the Southwest, first as a petroleum geologist with J. M. Guffey Petroleum Company, which merged into the Gulf Production Company, and then as an independent consulting geologist. He was appointed director of the survey on 7 May 1943.

During a long career, he has served as a delegate representing the United States at several important international scientific meetings, received honorary degrees of doctor of science from the Montana School of Mines, and Kentucky and Southern Methodist universities, and doctor of engineering from the Colorado School of Mines. In 1950 he was awarded the Anthony F. Lucas petroleum medal, and in 1954 the John Fritz medal.

HANS WINTERSTEIN, research professor of physiology at the Institute of Physiology, University of Istanbul, Istanbul, Turkey, recently delivered the Harvard Medical School's Edward K. Dunham lectures. The theme this year was *The Chemical Control of Pulmonary Ventilation*.

L. EARLE ARNOW, vice president and director of research for Sharp and Dohme, a division of Merck and Company, Inc., was awarded the University of Minnesota Outstanding Achievement Award during the recent meeting of the American Chemical Society that took place at the university. Arnow, who received both his Ph.D. and M.D. degrees from Minnesota, is a former member of the university's medical faculty.

WILLIAM R. HAWTHORNE has been appointed to the new faculty post of Jerome Clarke Hunsaker professor of aeronautical engineering at Massachusetts Institute of Technology for the current academic year. Hawthorne is on leave from Cambridge University, England, where he holds the Hopkinson and Imperial Chemical Industries professorship in applied thermodynamics. His principal interests are aircraft propulsion and advanced fluid mechanics; at M.I.T. Hawthorne will divide his teaching efforts in these fields between the departments of mechanical and aeronautical engineering.

VINCENT DU VIGNEAUD, professor of biochemistry at Cornell University Medical College, is to receive the Chandler medal from Columbia University in recognition of his contributions to the knowledge of biochemistry, his most recent achievement being the first synthesis of certain polypeptide hormones. The medal will be presented during a dinner-meeting at the Men's Faculty Club of Columbia on 9 Nov., when du Vigneaud will discuss the "Isolation and proof of structure of the vasopressins and the synthesis of octapeptide amides with pressor-antidiuretic activity."

ALBERT CAROZZI of the University of Geneva, Switzerland, is visiting lecturer in geology at the University of Illinois for the current academic year. He is teaching an undergraduate course in structural geology and a graduate course in tectonics.

MURIEL E. WARNER, former director of the American Medical Association microbiological laboratory, has recently joined the staff of Foster D. Snell, Inc., New York, consulting chemists, engineers and biologists. The firm plans to extend its services in the microbiological and pharmaceutical fields, especially in production control, process and product development, stability tests, legal problems, and assignments involving the various regulatory bodies.

ALBERT H. COOPER, professor of chemical engineering at the University of Maryland, has been named chairman of the department of chemical engineering at Pratt Institute. Cooper is also manager of the Pilot Engineering Co. and vice president and technical director of Chemchron Corp.

HENRY C. SMITH, associate professor of psychology at Michigan State University, has been granted a Fulbright award for 1955–56 to engage in research in industrial psychology at Società Umanitaria, Milan, Italy.

FREDERICK I. STONE, assistant for professional services to the vice chancellor, School of the Health Professions, University of Pittsburgh, and a member of the executive committee of the medical advisory board of the National Multiple Sclerosis Society, has been appointed director of the society's medical and scientific department. His primary responsibility will be to develop expanded research and medical programs; he will also administer all research grants and fellowships.

MELSON BARFIELD-CARTER of the radiology department of Alabama Medical Center, and JAMES R. GARBER, of the department of obstetrics, retired on 1 Aug. Both men had served since 1945 as chairmen of their respective departments.

ROGER H. CHARLIER of Chester, N.J., president of the New Jersey Academy of Science, has been appointed special lecturer in geology and physical geography at Hofstra College.

WALTER H. ZIMPFER, of the civil engineering staff of the University of Florida, has been granted a 1-year leave of absence to serve as assistant in the University Relations Division of the Oak Ridge Institute of Nuclear Studies. He succeeds WADE T. BATSON, who has resumed his post as associate professor of biology at the University of South Carolina.

SIMON RODBARD, former assistant director of the Medical Research Institute at Michael Reese Hospital, Chicago, Ill., has been appointed professor of experimental medicine at the University of Buffalo and director of its Chronic Disease Research Institute. He will conduct an intensive program of research and training in the cardiovascular field.

Necrology

RICHARD R. DEIMEL, Englewood, N.J.; 74; retired head of the mechanical engineering department of Stevens Institute of Technology; 28 Sept.

THOMAS MACKIE, Westport, Conn.; 60; tropical disease specialist, former professor at Columbia University, Cornell University, and Bowman-Grey School of Medicine; consultant in tropical medicine to the Secretary of War during World War II; 5 Oct.

KARL PAECH, Tübingen, Germany; 46; botanist and plant chemist, professor at the University of Tübingen; 28 July.

REV. LOUIS B. SNIDER, Chicago, Ill.; 42; psychologist, professor at Loyola University; 28 Sept.

ZATAE L. STRAW, Manchester, N.H.; 89; physician, first woman graduate of Dickinson College; 1 Oct.

LOUIS L. THURSTONE, Chapel Hill, N.C.; 68; retired professor of psychology at the University of Chicago and a member of the staff there for 28 years; president of the American Psychological Association in 1932; 29 Sept.

Education

■ University of California Extension is offering a course in aviation medicine this fall. The course, which is open to graduates of approved medical schools, will meet 26, 27, and 28 Oct. in the Religious Conference Building adjoining the university's Los Angeles campus. In addition to lectures by authorities on such subjects as aviation toxicology, psychology, and otolaryngology, the course will include a field trip to the Lockheed Aircraft Corporation in Burbank, Calif.

■ A research building designed for studies of the Khapra beetle, a serious pest of stored food products, will be constructed shortly on the Riverside campus of the University of California. The new structure will provide isolated facilities that will permit entomologists to observe the beetle without any danger of contaminating other buildings.

Facilities will include rooms for raising mass cultures of the pest, laboratories for checking the effectiveness of various control techniques, fumigation chambers, and equipment for formulating the many insecticides that will be tested. Experiments will be directed by David L. Lindgren and Glenn E. Carman.

■ The department of dentistry and division of dental research of the University of Rochester School of Medicine and Dentistry celebrated its 25th anniversary on 8 Oct. Day-long scientific sessions brought together a majority of the 58 former dental research fellows at the Rochester Medical Center, many of whom have since become deans, professors, and research directors in many parts of this country and abroad. The celebration was dedicated to George H. Whipple, emeritus dean of the School of Medicine and Dentistry and emeritus professor of pathology, who originated the dental research program.

About 20 reports were given describing new developments in dental research and education. Among the participants in the sessions in Whipple Auditorium were Alan Gregg, vice president of the Rockefeller Foundation, and A. LeRoy Johnson, emeritus dean of Harvard Dental School. They, as well as Whipple, spoke on the early history of the dental research and training program, which was begun and supported for 5 years by a substantial grant from the Rockefeller Foundation.

■ The Edward S. Harkness Memorial Hall was dedicated on 7 Oct. at Yale University. The 11-story building, which cost $2.75 million, will be a residential center for 266 medical students. Donald P. Shedd, assistant professor of surgery, has been named resident faculty member.

Grants, Fellowships, and Awards

■ During the next few months, college seniors and graduate science students throughout the United States will compete for more than 750 National Science Foundation fellowship awards for a year of graduate scientific study during the academic year 1956–57. Applications for the 1956–57 NSF fellowship program may be obtained from the Fellowship Office, National Research Council, Washington 25, D.C.

The closing dates for receipt of applications are *19 Dec.* for postdoctoral applicants and *3 Jan. 1956* for graduate students working toward advanced degrees in science. The selections will be announced on 15 Mar. 1956. These fellowships are awarded to American citizens who will begin, or continue, their studies at the graduate level in the mathematical, physical, biological, medical, engineering, and other sciences during the 1956–57 academic year.

For the first time this year, the foundation will award fellowships in fields of convergence between the natural sciences and the social sciences. Approximately 20 fellowships will be awarded in such overlapping areas as mathematical economics, demography, information and communication theory, and the history and philosophy of science.

Selections will be made solely on the basis of ability. The majority of the fellowships will go to graduate students seeking master's or doctor's degrees in science, although about 80 awards will be made to postdoctoral applicants. Graduating college seniors in the sciences who desire to enter graduate school are encouraged to apply for the awards.

The rating system for selection of predoctoral fellows will be based on: (i) test scores of scientific aptitude and achievement; (ii) academic records; (iii) written evaluations of each individual from his faculty advisers and other qualified observers. Postdoctoral applicants will not be required to take the examinations. Applicants will be rated by special fellowship panels established by the National Research Council. Final selection will be made by the National Science Foundation.

Stipends vary with the academic status of the fellows. First-year fellows—students entering graduate school for the first time or those who have had less than 1 year of graduate study—will receive annual stipends of $1400. Fellows who need one final academic year of training for the doctor's degree will receive annual stipends of $1800. Fellows between these groups will receive stipends at the rate of $1600 annually. The stipends for postdoctoral Fellows will be $3400 per year. Dependency allowances will be made to all married fellows. Tuition and laboratory fees and limited travel allowances will also be provided. Fellows may attend any accredited nonprofit institution of higher education in the United States or similar institutions abroad.

In 1952–53, the first year of the foundation's fellowship program, 624 candidates were chosen from approximately 3000 applicants. Last year 785 selections were made out of 3389 applicants, and about 1400 persons were named on an honorable mention list, which was made available to deans of graduate schools.

■ Two new fellowships have been established at Johns Hopkins University. These will permit staff members of the Hopkins Applied Physics Laboratory in Silver Spring, Md., to spend a year in one of the university's Baltimore divisions.

Those selected will be appointed William S. Parsons fellows; the fellowships are named in memory of a naval officer and scientist "who, through his understanding and encouragement of new technological advances made a lasting contribution to the military preparedness of this country and to the program of the Applied Physics Laboratory."

■ As one phase of its continuing aid to education, the Ethyl Corporation has announced the award of 19 graduate research fellowships in chemistry, chemical engineering, and mechanical engineering for the 1955–56 academic year. Total value of the awards is approximately $45,000.

Each fellowship provides the recipient with $1500 for living expenses and an allowance for tuition and fees. In addition, the college department concerned receives $500 for expenses in connection with the fellow's research work. The corporation has awarded fellowships at colleges and universities throughout the country annually since 1937.

■ The Division of Medical Sciences, National Academy of Sciences–National Research Council, 2101 Constitution Ave., Washington 25, D.C., is accepting applications for grants-in-aid of research in three specialized fields:

The Committee on Problems of Alcohol has available a limited fund for the support of grants. The committee is interested in fostering research, primarily on the physiological, biochemical, and pharmacological effects of alcohol. Applications for the fiscal year 1956–57 should be postmarked *not later than 15 Jan. 1956.*

The Committee for Research in Problems of Sex is concerned with encouraging research, primarily on the mechanisms controlling sexual behavior in animals and man. Proposals involving endocrinological, neurological, psychological, anthropological, phylogenetic, and genetic studies directed toward this objective are therefore invited. Requests will also be considered that deal with the physiology of reproduction or with related biological and biochemical fields. Applications for the fiscal year 1956–57 should be postmarked *on or before 1 Feb. 1956.*

The Committee on Drug Addiction and Narcotics may have available for the coming year limited resources for the support of research in the fields of analgesia and addiction. The committee also invites information on basic research being carried on in these fields, in order that it may extend its activities as a center for the exchange of information on current investigations in this area.

■ At a recent meeting of the Ohio State University's board of trustees, 22 contracts totaling $624,538.84 for research projects supported by Government and industry were reported. Most of the research agreements, which are administered by the Ohio State University Research Foundation, represented continuations of projects already under way.

Largest of the studies, with a contract for $161,802 with the Air Research and Development Command, Baltimore, Md., called for further research by the department of chemistry on oxidation of hydrocarbons. Another contract, for $92,000, continued studies in the department of psychology on "human engineering of air traffic control systems" for the Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio.

■ The Chaim Weizmann memorial fellowships have been announced. These are tenable at the Weizmann Institute of Science, Rehovoth, Israel. The work of the institute is chiefly devoted to fundamental research in the exact sciences. Awards will be made to scientists who have done meritorious postdoctoral research.

The stipend, including fare, for an unmarried fellow coming from Europe will be $3500 ($4000 from the United States or Far East). The stipend, including fare, for a married fellow bringing his family from Europe will be

$4500 ($5500 from the U.S. or Far East). It should be noted that the cost of living in Israel, measured in dollars, is considerably lower than that of the United States.

Applications will be accepted *until 15 Dec.* Further information may be obtained from the Academic Secretary, Weizmann Institute of Science, Rehovoth, Israel.

In the Laboratories

■ The Navy has completed a $41-million engine test laboratory in Trenton, N.J. The facility includes steel and concrete test cells—two altitude chambers, two jet engine sea-level test cells, and an altitude cell for turbo-prop engines.

The ram blower rigs can force more than a million cubic feet of air a minute past engines in the test cells; the heating systems are designed to simulate aerodynamic heating—the friction heat barrier that faces aircraft making sustained flights at supersonic speeds. The cooling systems can refrigerate air to – 67°F.

The equipment that has been installed can be used to simulate any desired variation of atmospheric temperature, density, and humidity encountered by aircraft from sea level to an altitude of 65,000 feet, at speeds far beyond that of sound.

A remotely operated electronic control system has a 35-foot graphic supervisory control panel, interlinked with 11 locally placed control panels, as its nerve center. More than 60 automatic instruments—level indicators, alarms, recorders, controllers, and indicators—register results of the engine tests. On one instrument the operator can dial any one of 300 different temperatures, ranging from – 200° to more than + 1200°F. More than 26 miles of thermocouple wire and 23 miles of copper tubing link test cells and electronic control boards.

David E. Dressendorfer of Springfield, Ill., laboratory superintendent, said that the new facilities will handle the bulk of the Navy's test and evaluation work on current and future jet and turbo-prop engines.

■ The Dow Corning Corporation of Midland, Mich., has been named winner of the 1955 award for chemical engineering achievement, given biennially for outstanding contribution to the chemical engineering field by *Chemical Engineering*, the McGraw-Hill publication that sponsors the award.

Walter G. Whitman of Massachusetts Institute of Technology, chairman of the award committee, will present the award at a dinner to be given on 7 Dec. in connection with the 25th biennial Exposition of the Chemical Industries at the Bellevue-Stratford Hotel, Philadelphia, Pa. Dow-Corning is being recognized for large-scale production and marketing of silicones, which were first produced by the company for military use during World War II.

■ International Business Machines Corporation has announced plans to establish a research and development laboratory in Zurich, Switzerland. It is expected to be in operation by the first of next year. The new laboratory will make possible closer contact between the domestic IBM organization and development activities being conducted by European scientists and engineers in the accounting and data-processing equipment field. Ambros P. Speiser, associate professor at the Swiss Federal Institute of Technology, has been appointed director of the laboratory. He will assume his new position after he completes his present work as head of the computer group at the institute.

■ A British proposal to build a $230-million steel plant in India has been accepted by the Indian Government as part of its plan to increase national steel production to 6 million tons a year. The plant, which will have an annual capacity of 1 million tons, will be India's third such government-owned undertaking. The Indian Government has previously contracted for Soviet- and German-built plants.

■ Murray E. Volk, who was formerly associated with Nuclear-Chicago, recently announced the organization of the Volk Radiochemical Company with offices and laboratories at 5412 North Clark St., Chicago, Ill. The new company will specialize in the manufacture and supply of compounds tagged with radioactive carbon, phosphorus, and sulfur.

■ The Du Pont Company will build a new sulfuric acid plant on a recently acquired site in Ohio near the confluence of the Ohio and Greater Miami rivers about 20 miles from Cincinnati. Construction is to start immediately and the plant is scheduled to open in the latter part of 1956.

To be known as the Fort Hill Works, the new unit will be operated by the company's Grasselli Chemicals Department. It will replace the plant now operated by Grasselli at Lockland, near Cincinnati.

Miscellaneous

■ Electronics specialists are urgently needed at the Corps of Engineers Research and Development Laboratories, Fort Belvoir, Va., to conduct basic and applied research on new devices for military use. The ERDL occupies a 240-acre wooded peninsula about 15 miles south of Washington, D.C. The electronics laboratory is devoted to the development of mine detectors and related equipment. Engineers working at ERDL have the opportunity of pursuing graduate studies at Government expense at Catholic University of America.

Applicants must hold a degree in electrical engineering, physics or mathematics, or have considerable practical research experience in their fields. Salaries range from $4345 to $8940 per year. Those interested should apply to Mr. Walter H. Spinks, Acting Executive Officer, Engineer Research and Development Laboratories, Fort Belvoir, Va.

■ A map showing known uranium deposits of the United States has been prepared by the Geological Survey on behalf of the U.S. Atomic Energy Commission. Studies in recent years have shown that although trace amounts of uranium occur nearly everywhere under extremely varied geologic conditions, concentrations large enough to warrant mining are restricted.

The principal uranium deposits in the United States are located in sandstone of the Colorado Plateau in Arizona, New Mexico, Colorado, and Utah, as well as in limestone in New Mexico. Important deposits in sandstone are also found in South Dakota and Wyoming.

The locations of the uranium deposits shown were established with the help of information gained from published and unpublished reports of the Atomic Energy Commission, its contractors, and the Geological Survey. Included are discoveries by private individuals, corporations, and Government agencies.

Published as MR 2 of the Survey's Mineral Investigations Resource Studies, the 34- by 52-inch map was compiled by R. W. Schnabel, Survey geologist. Copies may be ordered by mail at 50 cents each from the Geological Survey Distribution Center, Washington 25, D.C., and Federal Center, Denver 2, Colo.

Erratum: In the 21st line of the fifth paragraph of the article "Genetic damage produced by radiation," by H. J. Muller, in the issue of 17 June, page 837, the word *not* was inadvertently omitted. The sentence should have read: "This is why the group of responsible scientists who signed the official report on these investigations in Japan (*4*) stated that it had 'always been doubtful whether significant findings' could be obtained by the methods there used and pointed out that the inconclusive results, although *not* definitely positive, were at the same time 'entirely consistent with what is known of the radiation genetics of a wide variety of [other] material.' "

Erratum: In the article "Recent Geology of Cane Wash, Monument Valley, Arizona," by Charles B. Hunt, in the issue of 30 September, page 584, a line of type was unfortunately misplaced at the last moment. The next to the last sentence in the third column should read: "Upstream from the lake beds (Fig. 2) Cane Wash is aggrading the valley floor."

Reports and Letters

Rapid and Precise Measurement of Moisture in Biological Materials

The classical methods for determining water content either by drying to constant weight, or chemically as with the Karl Fischer reagent, are not entirely satisfactory. The most serious disadvantage of the first method is that it is tedious and time consuming, whereas the chemical method is difficult to apply without introducing traces of atmospheric moisture and must be repeatedly standardized against a known amount of water. Moreover, side reactions with some biological materials may occur, and the sample is lost.

This paper (*1*) describes a method, using an instrument similar to that devised by Anderson (*2*), that is fast and precise because the water is measured manometrically and the sample being tested is never exposed, even momentarily, to the atmosphere. Although the apparatus was designed for the specific purpose of determining residual moisture in dried biological material, it is useful for determining the moisture in air, foods, pharmaceuticals, and a wide variety of industrial products.

Figure 1 shows that the apparatus consists of four main parts: the condenser, *A*; manometer, *B*; device for attaching samples, *C* or *D*; and an interchangeable expansion chamber, *E*. The manometer measures the vapor pressure of the water; since the pressure is directly proportional to the amount of water and inversely proportional to the volume of the vapor, the apparatus is calibrated simply by measuring its volume.

For a given pressure the amount, or weight, of water can be calculated by the following formula.

$$W = P[V + PM]\,\frac{273 \times 18 \times 10 D_o}{T \times 22.4 \times 760 \times D_{Hg}},$$

where W is the weight of water in milligrams; P is the pressure of oil in centimeters; V is the volume of system at zero pressure in cubic centimeters; M is the amount of oil displaced per centimeter of pressure in milliliters; T is the absolute temperature in degrees; D_o is the density of oil at temperature T; and D_{Hg} is the density of mercury at temperature T.

Figure 2 shows the results obtained with known amounts of water. It is evident that the manometric method is accurate as well as precise, because the individual points deviated only slightly from the theoretical curve based on the equation given in the previous paragraph.

After the unit has been calibrated and completely dried, the manometer is filled to the zero level with a suitable low vapor pressure oil, the density of which has been determined. Octoil S was the most satisfactory of those tested.

To degas the oil, the entire system is evacuated to a pressure of less than 50 μ mercury, with stopcocks *G* and *H* open. Then, while pumping is continued, the left arm of the manometer is heated with a bunsen burner. The oil is rapidly degassed as the oil boils over through the stopcock *H* and down the right arm of the manometer.

Operation of the apparatus is divided into the following six steps.

1) Flame-sealed ampules and rubber stoppered bottles containing the samples are attached to the unit by means of adapters on a 10/30 standard taper connection (Fig. 1, *C* and *D*). The ampules are attached by means of adapter *C*, which consists of a 1-in. length of thin-walled metal tubing inserted within gum pressure tubing so that the latter extends about ¾ in. beyond both ends of the metal. The scored neck of the ampule is inserted so that the tip just enters the metal tube; it is held in this position by the distal portion of the rubber tubing. The bottles are attached by inserting the hypodermic needle of adapter *D* into the rubber stopper only far enough to occlude the bevel.

After the container is attached to the apparatus, stopcock *M* is opened and the air and water vapor are removed from the entire system, including the adapters, by continued evacuation through *F*.

2) The condenser is immersed in a dry ice ethanol bath after all air and water have been removed as indicated by a reading of 50 μ on a Pirani gage or by return of the manometer pressure to virtually zero.

3) After the condenser has cooled, the samples are connected to the system. The ampules are connected by breaking off the tip by bending at the point where the neck of the ampule enters the metal tubing, and the bottles are connected by pushing the needle through the rubber stopper.

4) The water is distilled over into the condenser either at room temperature or by immersing the bottle in a water bath (*L*). Since the amount of water that can be removed from a dried preparation is correlated with the temperature, the latter should be carefully controlled. Although 100°C may not denature dry proteins or kill microorganisms, it is safer to use a lower temperature, such as 50° or 60°C, in order to retain the biological activity of the sample after determining its moisture content.

It was observed that practically all of the moisture in our lyophilized preparations was removed in 10 minutes and that 95 percent was often distilled over in 3 minutes, but the temperature and time required should be determined for each type of material.

5) After stopcocks *F* and *M* have been closed, the condensed water is vaporized by removing the condenser from the cooling bath and placing it in water at room temperature. Although small variations in temperature produce only negligible effects on the pressure, the use of a constant temperature is recommended.

6) When stopcock *G* is left closed, 1 cm of oil pressure is equivalent to approximately 0.1 mg of water. Should the amount of water be sufficient to produce a pressure in excess of 25 cm of oil (about 3 mg of water) the volume of the system must be increased by opening stopcock *G*. If a 1000-ml flask is used as the reser-

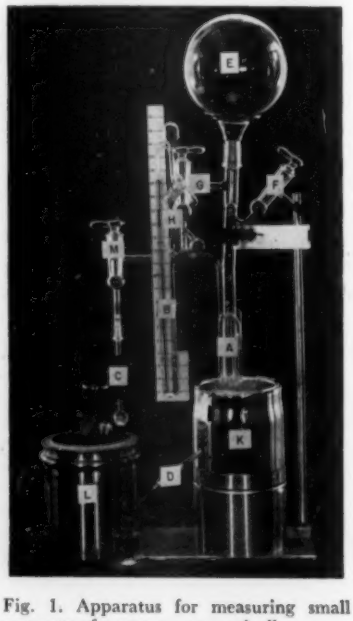


Fig. 1. Apparatus for measuring small amounts of water manometrically.

voir E, 1 cm of oil will be equivalent to about 1 mg of water. When the temperature of the apparatus has reached equilibrium, as indicated by a constant pressure, the manometer reading is recorded. The apparatus is readied for the next determination by opening stopcock *F* and trapping the water in a condenser placed in the vacuum line to the pump.

This apparatus can also be used to determine the pressure within the container before it is opened and can constitute the first step in the moisture determination. To do this, stopcock *F* is closed before the connection between the sample and the apparatus is completed (step 2). The total pressure within the sealed bottle is directly related to the observed pressure and can be obtained from an appropriate conversion graph similar to that used to obtain the amount of water.

Some time after the method had been in use in this laboratory, Beckett (*3*) described an apparatus for measuring moisture that is similar in function and principle to that described in this report. However, the unit described here differs in design and permits easier and more reliable operation. One important feature is the design of the manometer, which makes it convenient to degas the oil *in situ*. Another advantage in the construction is that, even though an error is made in manipulating the stopcocks, there is no possibility of sucking oil either into the pump or into other portions of the apparatus. A third advantage is that if the stopcock *H* is left closed the manometer can serve to check the operation of the instrument, obviating the use of a separate vacuum gage.

By exposing the bottle or ampule directly, temperature equilibrium between the sample and water bath can be achieved rapidly. Most of the procedures described in the literature use temperatures above 60°C but at relatively high pressures, that is, 50 to 100 mm of mercury. Because of the higher vacuum employed in this apparatus, comparable results may be obtained at lower temperatures. Since the temperature of the sample can be easily controlled, procedures are readily standardized to yield results comparable to those obtained by any other method.

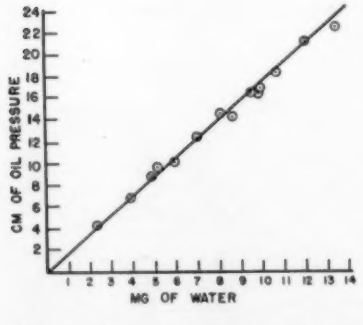


Fig. 2. Observed pressure of known amounts of water. The solid line represents the theoretical curve that is based on the volume of the apparatus; the points represent individual observations.

ROBERT J. HECKLY*
Naval Biological Laboratory,
Department of Bacteriology,
University of California, Berkeley

References and Notes

1. This work was supported by a contract between the University of California department of bacteriology and the Office of Naval Research. The opinions contained in this report are not to be construed as reflecting the views of the Navy Department or the Naval Service at large (article 1252, U.S. Navy Regulations).
2. A. W. Anderson, personal communication, 1950.
3. L. G. Beckett, in *Biological Applications of Freezing and Drying*, Ed. R. J. C. Harris (Academic Press, New York, 1954), p. 285.

* The assistance of Melvin N. Klumpp is gratefully acknowledged.

9 May 1955

Desiccator Cover Remover and Sleeve Wrench

The removal of desiccator covers (particularly glass desiccators) that have become tightly adhered has always been a problem. Use of desiccators in low temperatures, for long periods under vacuum, and with improper grades of seal grease, and so forth, are some of the common reasons for the tightly adhered covers. The ordinary means of removing the sticking covers can be hazardous because of the possibility of breaking the lid or desiccator jar; there is also the chance of spilling the samples in the desiccator during the operation. The use of glass desiccators that have a ground glass external collar with turbulature presents a similar problem. Occasionally these sleeves or collars are very difficult to turn, particularly if the desiccator is being used in low temperatures. When grasping the sleeve in an effort to turn it, and using the tabulature or side arm as a means of leverage, one is apt to break the tabulature; this often results in a serious injury to the operator. The following paragraphs describe a desiccator cover remover and a sleeve wrench that have been designed in our laboratory for performing the afore-mentioned operations in a safe and easy manner.

The cover remover is shown at bottom of Fig. 1. On the bottom jaw of the hand lever *A*, two tapered hard rubber rollers *B* are mounted on a ¼-inch pin through the jaw. A slot *C* is cut at an angle in the top jaw to receive the cross pull links *D*. The pull links are fastened through the openings of opposite sections of parallel brass sash chain *E*. The chain is drawn through rubber tubing that keeps it from becoming tangled and still allows flexibility. The cross pull links are made of ⅛-inch stainless steel rod threaded on both ends. Nuts on both sides of each chain section provide proper spacing between the chains and secure the pull links to the chain. The pull links are set at intervals along the chain to accommodate each size of desiccator cover. The ends of the chains are fastened to a hook that consists of an approximately 2-inch square brass plate *F* that is bent slightly to conform somewhat to the curvature of the cover. A ¼-inch square brass rod *G* bent slightly to conform to the outer circumference of the largest cover is soldered to the bottom along one end of the brass plate, forming the hook. Rubber tubing is placed over the handle of the lever to provide a better grip.

In operation, the proper pull link is engaged in the jaw slot and the end plate is placed so that the square rod is over the edge of the lip of the cover. The lever is then placed so that the chains pass over each side of the top of the cover and the rollers are under the flange of the desiccator proper. If the pull links are spaced properly, the handle of the lever should now be in a position slightly below horizontal. By holding down on the brass plate hook with one hand and pressing down on the lever handle with the other, the cover may be drawn across the desiccator far enough for easy removal.

The sleeve wrench is illustrated at top of Fig. 1. It consists of a pair of pivoted levers *A* the handles of which are bent slightly to bring them closer to parallel when they are in use. Rubber tubing *B* is placed over the handles to provide a better grip. One end of a piece of brass sash chain *C* is securely attached to the end of one of the levers. Pure gum rubber tubing is placed over the sash chain allowing a lip *D* of the tubing to cover the point where the chain is attached to the lever. Single extra chain links *E* are attached to the chain at proper intervals through holes cut in the rubber tubing. The extra links are attached in such a way that the loop end may be slipped over a pin *F* that is fastened in the end of the opposite lever. The locations of the extra links are determined by the diameters of the glass sleeves of the desiccators in use. The ex-

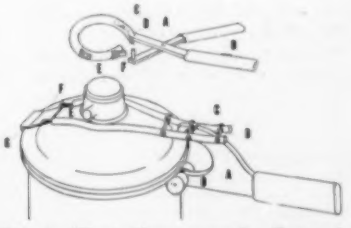


Fig. 1. (Top) Sleeve wrench; (bottom) cover remover.

tra link attached to the chain to accommodate the largest diameter sleeve should be placed one link from the end of the chain so that the rubber tubing extends beyond the extra link, thus providing complete rubber contact with the glass sleeve.

In use, the rubber covered chain is looped around the sleeve and the appropriate projecting link is slipped over the pin. Pressure on the handles clamps the chain around the desiccator sleeve, and the rubber tubing affords a good grip on the glass. The sleeve can then be turned in either direction.

HOWARD BRUBACH
National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, Bethesda, Maryland

28 June 1955

Germicidal Activity of Electric Heaters

Relatively little information is available concerning the possible secondary effect of various heat sources on the microbial population of room air. It appeared reasonable that a reduction in numbers might be induced by electric heaters, particularly those of a type in which a considerable amount of the heat generated is distributed by convection currents through the heater rather than by radiation. The higher temperature of the air in the immediate vicinity of the heater element, as well as inactivation or incineration of the biological agent on striking a hot surface, could be effective in reducing the numbers of air-borne organisms. Wesix heaters were selected for the tests since they are of a type (*1*) through which air circulates quite rapidly through and around a ceramic chimney (900 to 1200°F) supporting the heating element (1100 to 1500°F).

Tests (*2*), to be reported in detail elsewhere, were conducted to determine (i) the direct germicidal action exerted when suspensions of bacteria, bacterial spores, or bacteriophages were nebulized in such a manner that a continuous stream of the aerosol passed through the heater core; (ii) the effect of the heater in an experimental room in which the population could be controlled; and (iii) the influence of a heater on the air-borne microbial population in rooms of my home.

Results of tests of type one and two indicated that the heaters did exert rather marked bactericidal, sporicidal, and viricidal activity. For example, direct passage of aerosols through the heater indicated a reduction in numbers of viable spores of the order of 50 to 75 percent, of around 90 percent for bacteria, and around 99 percent for a bacteriophage.

Tests of type three are of more general interest because they were designed to determine the reduction in numbers of air-borne microorganisms during normal operation of a heater in the home. Representative samples of air were passed through broth in an impinger flask (*3*), the numbers of viable spores and bacteria collected therein being determined by ordinary dilution and plating techniques. In some tests, the air was also sampled with the aid of Millipore filters. The two methods yielded similar results, but dilution and plating were better adapted to wide variations in numbers of organisms sampled.

The tests were carried out on different days and in different rooms under normal conditions in the home; the numbers of bacteria, therefore, showed considerable variation. Counts made on replicate samples of air, however, agreed quite closely with each other—for example, 73 and 75 colonies developed from 100 liters of air sampled 1 and 2 hours before the heater was used. Results of a number of tests are summarized in Table 1. The percentage reductions (including higher fungi developing during incubation for 72 hours) noted after 1 hour ranged from 46 to 56 percent and in the following hour from 30 to 80 percent. Plate counts of organisms settling out from the air indicated similar reductions. Different patterns of air circulation in the room and through the heater are responsible in part for the marked variations noted over longer test periods. Similar tests carried out with a wall-type heater rather than a floor model gave results of the same general nature (see Table 1).

The results of this study indicate that in addition to their primary heating function, electric heaters of the type described do exert germicidal activity during the time they are in operation in experimental chambers or in rooms in a home. In the latter case, rates of reduction of air-borne microorganisms were in the general range of 50 percent per hour.

C. E. CLIFTON
Department of Medical Microbiology, Stanford University, California

Table 1. Effect of electric heaters on the microbial population of air in various rooms of a home under normal conditions of use. Temperature range of 69° to 72°F.

Location	Air sample (liters)	Colony counts (Hours)		
		0	1	2
Bedroom	40	88	44	8
Bedroom-study	35*	188	99	
Dining room	50	25	11	7
Dining room	100	74	43	31
Dining room	†	54	23	8
Dining room	100	16	8	3
Dining room‡	100	66	19	6
Dining room	†	68	21	14

* Millipore filters used for assay.
† Numbers settling on agar in petri dish in 15 minutes.
‡ Wall-type heater instead of floor-model heater.

References and Notes

1. J. C. Beckett, *Am. Inst. Elec. Engrs. Applications and Industry* 73, part 2, 161 (1954).
2. Grateful acknowledgment is made to A. P. Krueger and J. C. Beckett for helpful advice.
3. T. Rosebury, *Experimental Air-borne Infection* (Williams and Wilkins, Baltimore, Md., 1947).

22 August 1955

Disposable Petri-Type Dish

It has been possible to have fabricated a petri-type dish from paper and plastic materials. This dish is fully reliable for usual bacteriological uses and is inexpensive enough to be discarded after it has been used once.

Figure 1 shows the appearance of the currently available (A. S. Aloe Co., St. Louis, Mo.) disposable petri dish. The left portion of the illustration shows an opened dish. The top stands on edge above the bottom dish. The right portion shows two streaked plates.

Dimensions are approximately those of the standard 90-millimeter diameter glass petri dish. Walls are constructed of heavy paper and tops and bottoms consist of cellophane or similar transparent plastic material. The plastic bottoms and tops are sealed in their marginal portions to the walls by adhesives applied under pressure.

The assembled dishes, which need not be washed, can be sterilized in the autoclave (115 to 120°C for 15 minutes or longer); the sterilization does not cause any discernible change or distortion in shape or composition of the materials employed in manufacture of the dishes. Dry air sterilization cannot be employed because the plastic is unstable at high, dry temperatures and is destroyed.

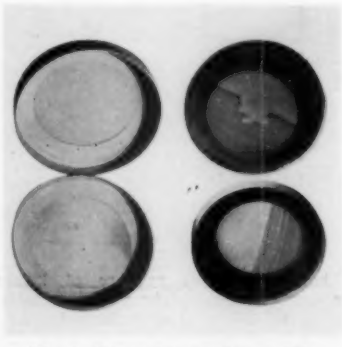


Fig. 1. Disposable petri-type dish.

Agar media are prepared and poured into the dishes in the conventional fashion. After use, the dishes may be sterilized by the use of chemical disinfectants, by incineration, or by autoclaving and then discarded.

The disposable dishes have been employed for routine work in this research laboratory and in the bacteriology section of the clinical laboratories at the Latter Day Saints Hospital, Salt Lake City, Utah. Comparative tests have shown that results similar to those obtained with the usual glass product are obtained with the paper dishes.

Certain advantages of the disposable paper and plastic petri dish are significant; for example, the problems accompanying accumulations of dirty dishes are relieved; experiments involving the use of larger than usual numbers of dishes can be carried out without burden to the budget or inventory.

STANLEY MARCUS
Department of Bacteriology,
College of Medicine,
University of Utah,
Salt Lake City

20 June 1955

Sterile Microdissection and Isolation of Malarial Oocysts

In connection with the study of the growth of malarial oocysts *in vitro* (*1*), the following technique was developed for sterile dissection and successive transfer of the oocysts in hanging drops (*2*).

A chamber of dimensions 35 by 40 by 22 cm (Fig. 1) was made with three walls of sheet metal, a plastic sleeve in front for insertion of one's hands, and a Lucite top with an opening for the body of a dissecting microscope (*3*). This opening was sealed by an elastic rubber membrane.

In addition to the fluorescent light in the chamber, two study lamps were used on the outside, each with a water-filled 50-ml flask on the Lucite top to focus the light on the object. A little ammoniated copper sulfate was added to the water for better contrast.

The illumination of the object was further strengthened by replacing the glass-plate stage of the dissecting microscope with a piece of Bakelite, in the center of which a hole was drilled that corresponded in place and size to the visual field of the low-power objectives. With this device, good contrast and a well-defined outline of the object were obtained.

Micro dissecting instruments were made from fine steel wire with ends ground into a point or a cutting edge. A pair was held by soft copper wire sheathed in plastic, one member being

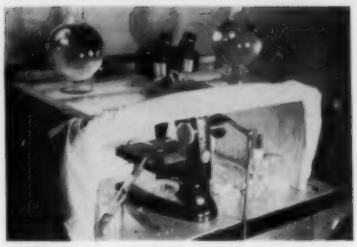


Fig. 1. Chamber equipped for sterile microdissection.

fastened through the slit provided for an arm rest at either side of the stage. The handle, made from glass rod, was held by many turns of the wire, which was looped at the base so that the instrument could be directed to any position or else bent down under the stage while it was not in use.

A foot-pedaled focusing device was provided in order to free the operator's hands for dissection. This device was composed of a ring fastened by a screw to the focusing knob and hinged to a steel rod, which was in turn hinged to the foot pedal.

The chamber was first sprayed with 75-percent alcohol and then equipped with all necessary sterile articles and materials so that it would be self-sufficient after the operation was under way. These articles were a dropping bottle of Ringer's solution, a test tube fitted with a medicine dropper and containing the culture medium, a covered dish of hexylresorcinol (1:1000), petri dishes with glass slides and coverslips, dissecting instruments, and depression slides ringed with petrolatum.

A previously sterilized covered jar containing petrolatum and a section of glass tubing with a diameter slightly larger than the circle of the depression slide was heated until the petrolatum melted. The jar was then sprayed with alcohol and placed quickly in the chamber. Rings of petrolatum were made by setting the glass tubing on the depresison slides, which were then placed upside down on a rack in the petri dish.

The chamber was also provided with sterile tissue paper contained in a small box taped against the side wall. The slit opening of this box was covered by a glass plate hinged above with adhesive tape. Pieces of paper to wipe off the tips of the dissecting instruments could be easily pulled out from the slit; the glass plate served as a protection against contamination.

After the afore-mentioned articles had been placed in the chamber, the chamber was sprayed with alcohol a second time and the operation proceeded as follows. The mosquito to be dissected was immobilized by carbon dioxide and then brushed free of scales. Both the oral and the anal openings were sealed by touching them to a fresh surface of Duco cement. After the cement had hardened, the insect was placed in the chamber and dipped for a few seconds in hexylresorcinol. It was then washed through 8 or 9 drops of Ringer's solution on slides and was ready for dissection.

The Duco cement not only prevented contamination of the Ringer's solution by the contents of the digestive tract but also kept the insect from floating; thus it made the dissection easier. In dissection, care had to be taken not to cut through the digestive tract. Usually, two operations could be made on a single stomach, which nevertheless continued to contract hours after it had been cut provided that the Ringer's solution was changed frequently.

Neither a micropipet nor a microspatula was successful in transferring oocysts. But by means of a "ferry," the oocysts were transferred successfully from drop to drop of Ringer's solution for washing, and from drop to drop of medium for culturing. The "ferry" was a fragment of broken No. 1 coverslip about 1 mm^2 in size. Such fragments were made beforehand in great numbers and only those with straight edges were chosen, since good straight edges alone could assure a sure grip with the fine points of the forceps. These selected glass fragments were sterilized in a small petri dish and kept inside the chamber.

After an oocyst had been cut out under the high power of the microscope, it was observed with low power and pushed by a microspatula to the center of the ferry. A slide was placed on the stage, and then a coverslip was placed on the slide. One or two drops of Ringer's solution and a drop of medium were placed on the slide for washing, and a drop of medium was put on the coverslip for culturing.

The ferry was picked up by a pair of fine forceps and washed in the drops of Ringer's solution and medium on the slide and was finally placed in the culture medium on the coverslip. It was then handled with the usual hanging drop technique. All of these steps had to be carried out without losing sight of the oocyst. By the techniques outlined here, oocysts of the size of 20 μ have been dissected and transferred successively to fresh medium for culturing.

JOWETT CHAO
Department of Zoology,
University of California, Los Angeles

References and Notes

1. G. H. Ball, *Exptl. Parasitol.* 3, 358 (1954).
2. This work was aided by grant No. 1857 from the U.S. Public Health Service and was suggested by Gordon H. Ball.
3. Thanks are due to Thomas W. James for the design of the chamber.

8 August 1955

Microinjector Needle for Determination of per os-LD_{50} of Insect Viruses

Advancement in the study of virus diseases of insects, as an important branch of insect pathology, continuously necessitates the development of new techniques. A frequent test run in the study of insect viruses is the determination of their median lethal dose by the dosage-mortality method. This test has been run in the following three ways: (i) injection of the test suspension into the body cavity of the insect (*1*); (ii) feeding the insects with food contaminated with a known amount of virus (*2*); and (iii) allowing insects, previously starved, to drink a droplet of known volume of virus suspension (*3*).

Although the first method gives very exact results, it does not permit drawing practical conclusions concerning the virulence under natural conditions, for the path of infection in nature is *per os* in almost every case. The second and third methods allow the determination of the *per os* virulence of the test suspensions; however, there are insects and insect stages on which these two methods cannot be applied, owing to the animals' particular feeding habits. Moreover, starving insects (method three) introduces an unnatural factor of unknown value into the experiment.

In studying a granulosis virus of the tortricid *Zeiraphera griseana* (Hübner), the larch bud moth (*4*), I was faced with the problem of testing the *per os*-LD_{50} of the virus with fourth instar larvae of this insect (6 to 9 mm long). These larvae web the newly sprouting larch needles together to form a shelter within which they feed. Neither the feeding of needles contaminated with a given amount of virus nor the feeding of droplets of virus suspensions to larvae starved up to 48 hours was successful with this insect. Therefore, I devised a method, in 1954, that enabled me to introduce, through the mouth of the insect, the appropriate amount of virus directly into the larval gut without leaving any traumatic lesions.

The type of syringe used for this purpose is a slightly modified Dutky-Fest microinjector (*5*). The most important

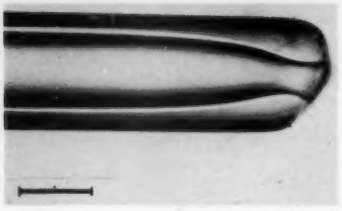


Fig. 2. Tip of the capillary glass needle after melting on a small flame. Outer diameter, 160 μ.

part is the needle (Fig. 1), which is prepared in the following way: a normal hypodermic injection needle (gage 20) is cut off 6 mm from its base, *A*, and a capillary glass tube 100 mm long, *B*, is sealed to the needle stump with melted sealing wax, *C*. The tip of the glass tube is then drawn in the flame of a bunsen burner to a very fine capillary with an outer diameter of approximately 150 μ. This thin capillary, which is very flexible, is broken with a forceps at a distance of about 20 mm from its base. The tip of the fine capillary is then heated very carefully at the bottom of a small flame. The melting of the glass occurs almost instantaneously, and some skill is required to obtain the correct shape of the needle tip, avoiding complete occlusion of the capillary (Fig. 2).

The microinjector is fixed on a stand, and the tip of the needle reaches into the field of the microscope. The larva to be injected is set on a 6- by 6-cm sterilized slip of paper, and this paper with larva on it is then placed in a petri dish, where the insect is anesthetized for 30 seconds under ether, in this case. The paper with the anesthetized larva is lifted out of the petri dish by means of forceps and brought under the microscope so that the larva lies with its mouth parts near the needle tip. The larva is delicately held behind the head capsule with a fine forceps and its head is lifted until the mouth parts touch the needle tip. After application of a slight pressure in the direction of the needle, the mouth opens and the head capsule is slid onto the capillary, which penetrates about 1 mm.

The hypodermic needle and the glass capillary must be sterilized previous to the sealing; the preparation of the capillary needle tip must be performed under sterile conditions. Large series of this capillary needle should be prepared in advance and stored sterile if large numbers of insects are to be tested.

MAURO E. MARTIGNONI
Laboratory of Entomology,
Swiss Forest Research Station,
Zurich, Switzerland

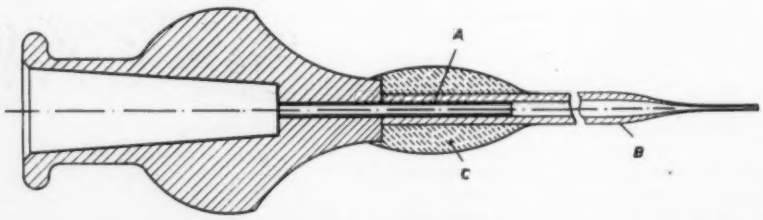


Fig. 1. Microinjection needle. *A*, stump of normal hypodermic injection needle (gage 20); *B*, capillary glass tube; *C*, sealing wax.

References

1. G. H. Bergold, *Biol. Zentr.* **61**, 158 (1941); *Can. J. Zool.* **29**, 17 (1951); N. Plus, *Bull. Biol. France et Belg.* **88**, 248 (1954).
2. Y. Tanada, *Proc. Hawaiian Entomol. Soc.* **15**, 235 (1953).
3. F. T. Bird and M. M. Whalen, *Can. Entomologist* **85**, 433 (1953).
4. M. E. Martignoni, *Mitt. Schweiz. Entomol. Ges.* **27**, 147 (1954).
5. S. R. Dutky and W. C. Fest, Microinjector. U.S. Pat. 2,270,804. *Offic. Gaz.*, U.S. Pat. Office **534**, 673 (1942).

30 June 1955

High-Vacuum Filament Furnace for Gas Analysis of Metals

There are several methods currently employed to determine the gaseous content of metals, each having certain advantages as well as inherent disadvantages. The main disadvantage of all of these methods is their limited field of application.

Probably the most versatile and widely used method at present is that of vacuum fusion (*1*). This method requires complex apparatus and multiple, time-consuming operations for furnishing quantitative data on the oxygen, hydrogen, and nitrogen content of a metallic specimen. Although satisfactory results can be obtained for most metals, the method allows no further qualitative determinations and is not well suited to such operations as rate studies and others.

The so-called hot-extraction method (*2*) is a simpler technique that requires neither the complex apparatus nor the time-consuming operations, but it is strictly limited to the determination of hydrogen.

Another recently developed method that involves the measurement of equilibrium pressures (*3*) has advantages in apparatus and operational simplicity equivalent to those of the hot-extraction method, and it appears to be capable of slightly greater accuracy. However, this method has at present been applied only to hydrogen determinations in titanium.

Notwithstanding the variations in techniques, these methods have in common a dependency on direct pressure measurements for all analytic determinations.

The ideal instrument for the measurement of such gaseous components is the mass spectrometer. It is possible to trans-

fer to the mass spectrometer the gases collected during any of the operations previously mentioned. However, it is more desirable to study these gases directly as they are effused from a furnace assembly that is an integral part of the inlet system of the mass spectrometer (*4*).

Of the many types of apparatus that have been designed for the study of gas-metal systems, few have been suitable for adaptation to a commercially available mass spectrometer. Specialized types of mass spectrometers, such as the solid-source instruments that are not yet commercially available, usually have the furnace unit incorporated within the ion source (*5*). The filament-type furnace reported in this paper (*6*) has been designed for adaptation to the conventional mass spectrometer.

The housing of the furnace, as shown in Fig. 1, is fabricated of Pyrex. The bottom section of the housing is fitted to a brass base section through the medium of a glass-to-metal seal. The base section is bolted to a base plate; the assembly is vacuum sealed by means of a Teflon "O" ring, as shown.

The sample support rods, which also serve as electric leads, are attached to the base assembly. One of these is electrically insulated (and made vacuum tight) by means of a Teflon gasket assembly. The other is screwed directly into the base plate, through which the electric circuit is completed.

The metallic specimen to be studied is installed as a small filament between the two nickel support rods, which are connected to a low-voltage, high-current source. The use of nickel for these rods

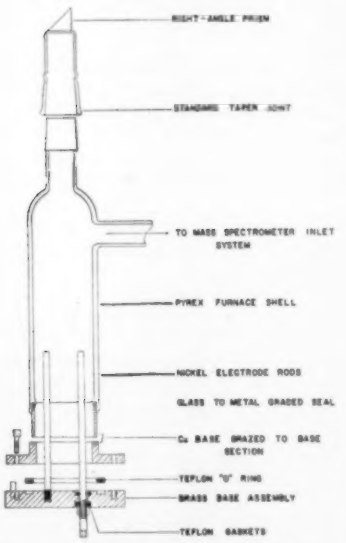


Fig. 1. Housing of high-vacuum filament furnace.

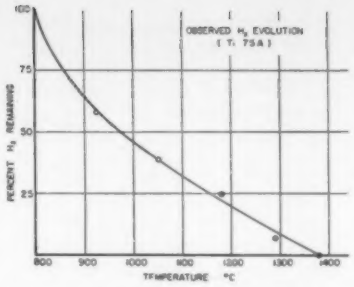


Fig. 2. Preliminary data obtained with high-vacuum filament furnace in a study of hydrogen evolution from titanium.

represents a practical compromise that was found after experimentation with several types. We sought adequate electric conductivity combined with low thermal conductivity. The effect of conduction heating and subsequent outgassing of these rods in contact with the hot filament has so far been found to be negligible. The use of resistance heating in this manner affords closer temperature control and is much simpler in operation and more economical in installation than induction heating.

In place of the sample filament, a small tantalum, tungsten or iridium coil or crucible may be installed between the rods to accommodate a massive specimen or a small heater crucible that would be conductively heated. The outgassing of this associated material can be determined and subsequent data corrected for its effect.

A right-angle, optically ground prism attached to the top of the furnace provides an optical path by which temperature measurements can be made by means of an optical pyrometer. The standard taper joint is incorporated to facilitate removal of any deposit that may obstruct the optical path. The entire furnace may be readily disassembled for cleaning or sample installation.

The furnace is connected to the inlet system of the mass spectrometer through a line that leads directly into the ionization chamber of that instrument. The entire system is evacuated by an oil-diffusion pump and a supporting mechanical pump that are an integral part of the vacuum system of the mass spectrometer.

Gaseous molecules, as they are effused from the heated sample, are passed through the line leading into the ionization chamber, where they are ionized by bombardment with electrons that are thermionically emitted from a tungsten filament. The resulting positive ions are accelerated by an electrostatic field, then deflected through a magnetic field that produces a spectrum of the ions according to their mass-to-charge ratios. By varying the strength of the electrostatic or magnetic fields, it is possible to bring into focus, at the collector plate, ions at any desired position within this mass spectrum. The signal produced by this ion current at the collector electrode is amplified and recorded.

It is possible, therefore, to scan the spectrum to identify all of the various components of the effused gases. Or, by "fixing" the electrostatic and magnetic fields of the instrument, it is possible to "sit" at any mass position. The amplitude of the recorded signal is quantitatively proportional to the partial pressure of the component being measured. By properly calibrating the inlet system, quantitative determinations can readily be made.

Various diffusion-rate determinations, investigations of outgassing characteristics, reaction kinetic studies, and so forth, as well as quantitative analytic measurements, may be made by correlating such data to imposed conditions of time and temperature.

To illustrate an application, some preliminary data obtained in a study of hydrogen evolution from titanium (commercially available Ti-75 A) are shown in Fig. 2. The observed effusion rate of hydrogen is plotted as a function of temperature with time-rate a constant (30 min between plotted points). As can be seen from the curve, the evolution of hydrogen is complete at a point just below 1400°C. Further increase in temperature resulted in no further hydrogen evolution. In the vicinity of 1400°C, hydrogen evolution is very rapid—quantitative removal is observed in less than 10 min at this temperature.

It is not intended that this method should supplant others currently in use that may be more practical or even superior for particular or routine applications. However, it is hoped that this idea may begin to answer the need for a more versatile method that is capable of furnishing some previously missing data that will aid in furthering studies of gas-metal interactions.

GEORGE A. CONSOLAZIO
WILLIAM J. MCMAHON
Ordnance Corps, Watertown Arsenal Laboratory, Watertown, Massachusetts

References and Notes

1. R. A. Yeaton, *Vacuum* **2**, 115 (1952).
2. R. K. Young and D. W. Cleaves, private communication.
3. T. D. McKinley, *J. Electrochem. Soc.* **102**, 117 (1955).
4. W. M. Hickam, *Anal. Chem.* **24**, 362 (1952).
5. A. J. Demster, *Phys. Rev.* **20**, 631 (1922); W. Bleakney, *ibid.* **40**, 496 (1932); A. O. Nier, *ibid.* **53**, 282 (1938); J. R. Walton, U.S. Atomic Energy Comm. Rept. ORNL 1473 (1953).
6. The opinions expressed are those of the authors and do not necessarily reflect those of the Ordnance Corps.

18 April 1955

Microextraction for Paper Chromatography

The dimensions of plant analysis have changed very much since the invention of paper chromatography [R. Consden, A. H. Gordon, A. J. P. Martin, *Biochem. J.* **38**, 224 (1944)]. This paper describes a microextraction method with which serial extractions can be made from the very small amounts of tissue actually needed for paper chromatography.

An extraction apparatus of the Soxhlet type cannot be made very small because the capillarity of the glass tubing prevents proper working. Figure 1 shows an apparatus that uses the refluxing principle of the Soxhlet; however, the construction of this apparatus is simpler. The condensing solvent causes a continuous flow from the condenser through the side arm that contains the tissue pieces and back to the boiling solvent in the flask. The capacity of the flask is about 5 milliliters. The capacity of the side arm can be adapted to the size of tissue by the choice of the position (Fig. 1). To close flask and side arm, ground glass stoppers are the best; if cork stoppers are used, they must be wrapped with aluminum foil to prevent extraction of material from the cork. To prevent delayed boiling (bumping), the apparatus has to be shaken a little. The flask should contain one glass boiling ball, especially with the use of solvents with a high heat of vaporization such as water.

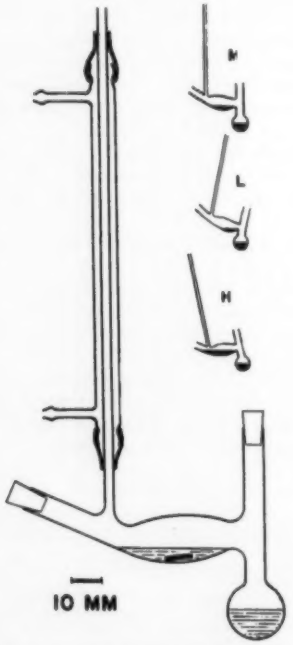


Fig. 1. Extraction apparatus. Positions for medium, low, and high capacity of side arm: *M*, *L*, and *H*, respectively.

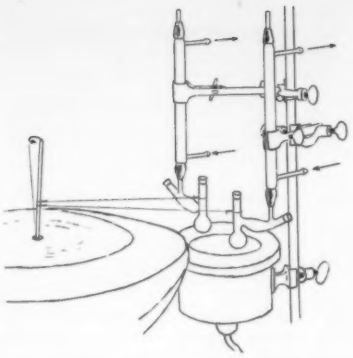


Fig. 2. Assembly for two simultaneous extractions.

Figure 2 shows the assembly for two simultaneous extractions. On the left side there is an old centrifuge running on slowest speed. A wooden stick is mounted slightly eccentric to the axis. The flasks are connected with the wooden stick by a thin wire. The slight back and forth movement of the flasks is actually a rotating one in an arc around the condenser jacket, which is fixed to the support. The flask, the side arm, and the inner tube of the condenser are one piece, the latter being connected with the condenser jacket by short pieces of rubber tubing. Five of these sets, consisting of two extractors with one heater on a support, can be placed around the centrifuge; this permits ten simultaneous extractions.

The whole assembly having been set up, the tissue is introduced into the side arm. Sufficient solvent should be pipetted into the side arm so that it runs over into the flask and fills it to the desired level (Fig. 1).

When the extraction is finished, the solution has to be concentrated either by turning the apparatus into position *H* (Fig. 1) or by taking the solvent out of the side arm with a pipette. The condensing solvent now does not reflux into the flask but stays in the side arm. When the solution in the flask has been concentrated (this moment is very critical), the apparatus is turned around the condenser (condenser jacket fixed) off the heater. Condensation of the solution still vaporized will clean the wall of the flask as soon as the apparatus is removed from the heat. The concentrated solution can now be transferred onto the paper chromatogram. The extractors can then be pulled out of the condenser jackets and replaced by new ones. During the next extraction, the first set can be cleaned. Therefore only one set of condenser jackets, but two sets of extractors, are required for continuous extraction.

We have been using this extraction method for several months in our laboratory to extract sugars with pyridine from 30-milligram (fresh weight) samples of plant tissue for paper chromatographic analysis. Extraction is complete after about 1 hour.

MARTIN H. ZIMMERMANN
Harvard University, Cabot Foundation, Petersham, Massachusetts

11 March 1955

Slide Projection from Lecture Table

For several years in our department, we have employed with satisfaction a device (Fig. 1) that enables a lecturer to project his own slides from the lecture table. Although we have some reservation concerning the originality of this arrangement, we have not seen it described by others. A schematic view of our original experimental installation has been published [*Southern Chemist* **13**, 73 (1953)]. Inasmuch as this device has interested many visitors to our department, we have decided to describe it for a larger audience.

We project the slide to a mirror suspended just below the ceiling of the room, the image being reflected to a screen behind the lecture table. If we employ the standard 3¼ by 4-inch slide in a Spencer delineascope with a lens of 14-inch focal length and with distances between lantern, mirror, and screen as shown, the image on the screen has outside dimensions of 56 by 71 inches. With a good quality plate glass mirror there is no appreciable distortion or light absorption.

The size of the exposed surface of our framed mirror is 24 by 29 inches. Local conditions determine the method of suspending the mirror from the ceiling. In our new building, we were able to obtain an excellent installation by having a gal-

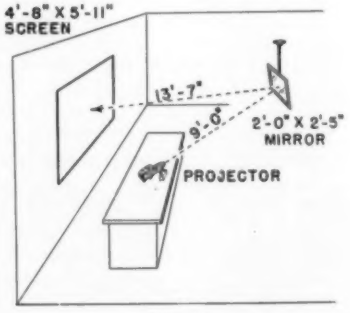


Fig. 1

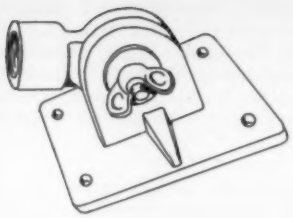


Fig. 2

vanized pipe nipple for 1½-inch pipe fixed in the concrete ceiling of the room when the slab was poured. A suitable length of pipe is attached to this nipple by a sleeve. The pipe screws into the heavy cast iron clamp illustrated in Fig. 2. This clamp (made to our specifications at a local foundry) is fastened by screws through the plate side to the back of the mirror frame. With this type of installation, the mirror is readily adjustable in both horizontal and vertical planes.

Inasmuch as our lantern cannot otherwise be tilted upward sufficiently, we mount it on a small sloped wooden platform. At the resulting angle, the light beam from lantern to mirror is not seen by the audience.

THOMAS P. NASH, JR.
Division of Chemistry, University of Tennessee, Memphis

27 June 1955

Anaerobic Cuvette

Studies of hemoproteins often require measurements of anaerobic reactions in a spectrophotometer. Recently Lazarow and Cooperstein (*1*) described a device that is especially suited for reactions involving catalytic hydrogenation. For some time, a somewhat different apparatus that allows anaerobic titrations, as well as additions from two sidearms, has been used in this laboratory (Johnson Foundation) and is described here because it may be useful for a variety of other studies as well (*2*).

The apparatus consists of two parts: the cuvette proper and a titration head (Fig. 1). The 1-centimeter cuvette fits into a Beckman cellholder. Two sidearms, B_1 and B_2, hold reagents to be mixed after the system has been gassed. There is a ground glass joint, *C*, between the cuvette and the titration head.

For anaerobic titrations, the sidearms and the burette *F* are left empty (*3*). The apparatus is evacuated and filled with an inert gas repeatedly, using stopcocks *D*. The burette *F* and the tip *G* are then filled through side tube *H* with the help of a two-way stopcock *E*. Titration is started and the drop hanging from the tip is stirred into the solution after each addition. This is accomplished by moving a magnetic flea between positions K_1 and K_2 with a magnet. In order to make an optical density measurement, the flea is stored in one of the sidearms (position K_3). Daylight is excluded from the apparatus with a black cloth.

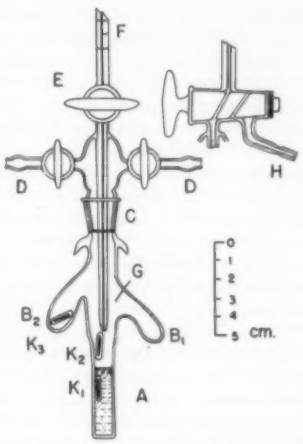


Fig. 1. Vacuum cuvette. Left, front view with upper end of the burette omitted. Right, side view of burette-filling mechanism. K_1, K_2, K_3, alternative positions of a magnetic flea. The other symbols are explained in the text.

If an addition of only one or two reagents is necessary, the titration head is removed and the gassing is performed by a two-way stopcock connected to a ground glass joint that fits into joint *C*. After anaerobic conditions have been obtained, the reagents in the sidearms are tipped in. This technique is essentially that of Ball *et al.* (*4*). Experimental results obtained using this system will be submitted elsewhere for publication.

A. C. MAEHLY
LUCILE SMITH
J. D. GRAHAM, SR.
Johnson Research Foundation and *Glassblowing Department, School of Medicine, University of Pennsylvania, Philadelphia*

References and Notes

1. A. Lazarow and S. J. Cooperstein, *Science* 120, 674 (1954).
2. This research was supported by a grant from the Division of Grants and Fellowships, National Institutes of Health, U.S. Public Health Service.
3. In some cases, the removal of O_2 can be perfected by the presence of some $Na_2S_2O_4$ in one of the sidearms.
4. E. G. Ball, C. F. Strittmatter, O. Cooper, *J. Biol. Chem.* 193, 635 (1951).

2 May 1955

A great discovery is not a terminus, but an avenue leading to regions hitherto unknown. We climb to the top of the peak, and find that it reveals to us another higher than any we have yet seen and so it goes on. The additions to our knowledge of physics made in a generation do not get smaller or less fundamental or less revolutionary as one generation succeeds another. The sum of our knowledge is not like what mathematicians call a convergent series . . . where the study of a few terms may give the general properties of the whole. Physics corresponds rather to the other type of series called divergent, where the terms which are added one after another do not get smaller and smaller, and where the conclusions we draw from the few terms we know cannot be trusted to be those we should draw if further knowledge were at our disposal.—J. J. THOMSON.

Book Reviews

Aluminum Paint and Powder. Junius D. Edwards and Robert I. Wray. Reinhold, New York, ed. 3, 1955. viii + 219 pp. Illus. $4.50.

The reader of this 219-page book by two men who have been the leaders in the development and increasing use of aluminum paint expects a clear, authoritative, and complete discussion of the subject, and he is not disappointed by this book. Well printed and copiously illustrated, the book gives a picture of the production and properties of aluminum powder and the formulation, properties, and uses of aluminum paint that is more complete than that available anywhere else. Other uses of aluminum powder and other varieties of the powder than those used in paint are also covered.

A discussion of methods of production is followed by a description of methods of testing the powder in the laboratory, the grading system used by Alcoa for the powder, and the uses of the different grades. Important precautions that should be observed in handling and storing the powder are mentioned.

The chapter on the composition of aluminum paint discusses the selection of the pigment grade and the formulation of the vehicle from the standpoint of the intended use of the paint. The kauri reduction test for the toughness of the vehicle is described and its importance is pointed out. Different types of varnish, lacquer, and synthetic resin vehicles are discussed and examples of their composition are given.

A chapter on aluminum paint in the protection of metals describes and illustrates various practical large-scale and laboratory tests of aluminum paint on steel. The importance of pigment concentration, vehicle viscosity, and composition are discussed and illustrated, as well as the preparation, priming, and painting of steel surfaces. The painting of aluminum, magnesium, and zinc, as well as special paint finishes such as the polychrome finishes used on automobiles, is also discussed.

Another chapter discusses the reflectance of aluminum paint, including that for ultraviolet and infrared radiation. The importance of the high visibility of aluminum paint on bridges and its high reflectivity for heat radiation on oil tanks is emphasized. The use of a properly formulated aluminum paint on the steel parts of furnaces to reduce thermal radiation and protect the metal is described and illustrated. The practical value of the opacity or "hiding power" of aluminum paint, its thermal and electric conductivity, and its resistance to penetration by water vapor are discussed. Figures are given for the effect on permeability of exposure to light and atmospheric influences for from 3 to 24 months for a variety of aluminum paints and other paints. Figures are also given that show the effect of such exposure on the tensile strength of the paint film, and the effect of hydrogen sulfide on the standard light-colored paints is discussed at an appropriate point.

The use of aluminum paint as a primer in the protection of wood is important, although it is not noticed as often as its use in the protection of steel. Tests at the Forest Products Laboratory and Aluminum Research Laboratories that show the ability of the aluminum primer to protect wood from the penetration of moisture and consequently to prevent warping and cracking of the wood are described and illustrated. Differences in the effects with different kinds of wood are noted. Proper vehicles for painting on wood are discussed and the advantages of "back painting" of lumber are pointed out.

The last chapter discusses the use of aluminum powder in other arts such as printing, coating of paper, plastics, powder metallurgy, and aeration of concrete. Practical experience and results in these fields are discussed. Pyrotechnic uses of aluminum powder—including its use as an additive to TNT in military explosives—are considered. The use of the powder in caulking compounds and cements, mold washes, the treatment of silicosis, and aeration of soap are also described.

It will be clear to the reader that aluminum powder has made great strides since World War I, when its application with "banana oil" lacquer to the decoration of radiators was about its only commercial use.

FRANCIS C. FRARY
Aluminum Company of America

Machine Translation of Languages. Fourteen essays. William N. Locke and A. Donald Booth, Eds. Massachusetts Institute of Technology, Cambridge, Mass.; Wiley, New York; Chapman and Hall, London, 1955. xii + 243 pp. $6.

Large-scale computers can now perform exceedingly complex operations, mathematical and logical. They can be programmed to process vast amounts of data. Their "memories," in the form of punched cards or magnetic tapes, for example, can be tremendous. If languages consisted only of vocabulary and grammar—with one-to-one correspondences in meaning between the words of one language and those of another, and with the grammars of each formalizable as sets of logical rules—then an automatic dictionary would be a matter of input-output equipment, large enough memory capacity, and means for memory searching (all these exist in computers already), and machine translation would be possible when the automatic dictionary is augmented by a logical computer programmed to transform from one set of rules to another.

The 14 essays and historical introduction of this book trace the developments in and grapple with the problems of this field in its manifold aspects, engineering and linguistic. In a sense, some are concerned with bridging the gap between the problem of translation between natural languages and the afore-mentioned problem, the soluble one of translating between two completely formalized languages. The first essay (Weaver) is historically significant not only as the first presentation, apparently, of the general problem but also because of the leads for further research disclosed therein. The next (Richens and Booth) deals with some actual methods of mechanical translation, and specimens thereof, illustrating how problems such as stripping off endings to get at the root or how the wider problem of getting to the semantic units of the communication can be approached.

The third essay (Oettinger) summarizes a thesis on the design of an automatic Russian-English technical dictionary. An experiment with monolingual volunteers showed with high probability that a scientist armed therewith could not only extract information clearly enough for his own purposes but could also communicate it to others. The next (Harper) goes into the syntax, morphology, and vocabulary of Russian, a specific mechanical translation procedure, and an example of its application. The eighth (Dostert) describes the Georgetown-I.B.M. experiment in which actual machine translation from Russian to English was done. The fifth essay (Bull, Africa, and Teich-

roew) goes in some detail into the problems of the "word," the interplay between dictionary and machine concepts of word, organization and size of machine memory and its connection with relative frequencies and other characteristics of language.

The sixth essay (Locke) deals with the possibility of spoken, rather than written input, the seventh (Booth) with storage (memory) devices, and the ninth (Reifler) with the mechanical determination of meaning. The emphasis is on German, for which somewhat detailed analysis is given. Grounds are shown to exist for hoping that human preediting (to match text to machine capabilities) or postediting (to make the raw output more palatable linguistically) can be eliminated. A simplified English suited to the machine is exhibited next (Dodd). It is readily comprehended and sufficiently close to conventional English that a trained typist could simultaneously translate and type the input with little loss of speed. It may well be less expensive to take this approach initially than to handle the raw natural language with a machine capable of dispensing with preediting. Some practical development problems (Perry) of the general field are then treated; these are followed by a discussion of idioms (Bar-Hillel). The notion that idioms might foredoom mechanical translation to failure was dispelled for this reviewer, for an enlarged dictionary and more complicated searching are most of what idioms entail. Logical concepts for syntax (Wundheiler) and a discussion of syntax and the problem of multiple meaning (Yngve) close the book.

The problem of technical translation alone is so pressing that development of mechanical methods is more than welcome. This book should be valuable not only as an excellent introduction to the field and a stimulus to further research; it may well help generate support for large-scale attack on the problem. It does not seem rash to assert that mechanical translation is not only possible but feasible and that it is fraught with profound implications for the future.

JEROME ROTHSTEIN
Signal Corps Engineering Laboratories

The Technology of Solvents and Plasticizers. Arthur K. Doolittle. Wiley, New York; Chapman and Hall, London, 1954. xv + 1056 pp. Illus. $18.50.

This book covers an astoundingly wide field of phenomena with a remarkable degree of detailed information and fundamental approach to all individual cases. For the scientific research worker, it is very valuable because it contains much factual and numerical data on a large number of important substances; for the chemist in industry, it is of equal importance because it provides him with simple and lucid explanations of such fundamental phenomena as solubility, compatibility, viscosity, and rheology. It is a real bridge between scientific approach and practical attitude; only a man like Doolittle, who is thoroughly and fully familiar with both fields and has contributed substantially to each of them, could successfully tackle this task and come out with a book of this scientific level and of this eminent practical usefulness.

First comes a general survey on solvent and plasticizer utilization and on the technology of resinous materials; there follows an enumeration of individual high polymers, such as cellulose nitrate, vinyl-type polymers, phenolics, urea- and melamine formaldehyde condensates, and other coatings and finishes.

The next chapters are devoted to the description of special adhesives and solvents, their physical properties, physiological action, and commercial handling.

Then three chapters that are more theoretical in character are added: viscosity of liquids, theory of solvent action, and principles of plasticization. A very complete and detailed description of the essential properties of all important plasticizers is given.

The text is presented in an attractive and pedagogic fashion; it contains many instructive tables and well-selected figures, which add a great deal to the educational character of this volume. Everybody who is interested in the field of solvents, resins, and plastics will profit greatly from this book and offer his thanks and appreciation to its author.

H. F. MARK
Polytechnic Institute of Brooklyn

Electroplating Engineering Handbook. A. Kenneth Graham and H. L. Pinkerton, Eds. Reinhold, New York, 1955. xix + 650 pp. $10.

This very complete compilation of engineering data has been assembled by a staff of associate editors and more than 40 experts in various phases of the electroplating industry. The authors of the chapters are identified and are all well-known experts. Each chapter is provided with a short list of references to the technical literature. A 10-page glossary follows the table of contents, and an adequate 24-page index is placed at the end.

The subject matter has been selected to assist a manufacturer to set up and equip a plant that will utilize electroplating procedures, starting with the selection of the plant location and layout, and including the specification of plating equipment, low-voltage d-c generators or rectifiers, materials to line tanks, ventilation systems, and finishing equipment. Part I, "General processing data," provides instruction in the methods of preparing the surface to be plated, compositions of plating baths and methods to analyze them, methods of testing the adhesion and quality of the electrodeposited metal; it discusses industrial hygiene and safety, and finally, reviews current practice in the important problem of waste disposal. Part II, "Engineering fundamentals and practice," is concerned more with plant design and operation, based on the extensive industrial experience of the editors and their collaborators.

This handbook, thus, is thoroughly practical, yet includes enough theory to support the recommendations. For example, in the chapter on "Rinsing," the applicable equations are developed to establish the most efficient rinsing cycles that utilize a minimum quantity of rinse water. A comparison is made of multiple countercurrent rinsing, spray rinsing, and spray and dip rinsing. The chapter even includes a discussion of ion-exchange resins to demineralize the effluent. Each phase of the electroplating industry is treated equally exhaustively.

This handbook will undoubtedly remain the standard reference work on commercial electroplating for a long time and will be used extensively in college courses in industrial chemistry and chemical engineering. In making it available, the editors and publishers have performed a useful service.

LAURENCE S. FOSTER
Belmont, Massachusetts

New Books

Glossary of Selected Geologic Terms. With special reference to their use in engineering. Colorado Scientific Society Proceedings, vol. 16. The Society, Denver, 1955. 165 pp. Paper, $2.75; cloth, $3.50.

My Hobby Is Collecting Rocks and Minerals. David E. Jensen. Hart, New York, 1955. 122 pp. $2.95.

Science and the Course of History. Pascual Jordan. Trans. by Ralph Manheim. Yale Univ. Press, New Haven, Conn.; Oxford Univ. Press, London, 1955. 139 pp. $2.50.

The Contriving Brain and the Skillful Hand in the United States. Something about history and philosophy of history. James C. Malin. The author, Lawrence, Kan., 1955. 436 pp. $3.50.

Problems and Control of Air Pollution. Proceedings of the First International Congress on Air Pollution held in New York City, 1–2 Mar. 1955, under the sponsorship of the Committee on Air-Pollution Controls of the American Society of Mechanical Engineers. Frederick S. Mallette, Ed. Reinhold, New York; Chapman & Hall, London, 1955. 272 pp. $7.50.

Scientific Meetings

University Computing Laboratories

A conference entitled "The Computing Laboratory in the University" was held at the University of Wisconsin 17–19 Aug. to focus attention on how computing laboratories fit into university programs and to obtain current opinions on trends.

Attendance was about 300 persons, representing higher educational institutions throughout the country. The effort to reach institutions not now active in the field was particularly successful.

In the keynote address, C. A. Elvehjem (University of Wisconsin) emphasized the universality of the use of digital computing equipment in the various branches of learning, including the social sciences. Universities, he said, should justifiably receive help for computing programs not only from federal grants but from foundations supporting research in the social sciences and humanities. Elvehjem noted that growth of numerical analysis and computing programs often can be achieved only through support by external sources of funds.

J. H. Curtiss (executive director, American Mathematical Society) gave a general address entitled "The role of computing in human affairs." J. W. Forrester (Massachusetts Institute of Technology) said that digital calculators serve educational institutions best and that analog equipment "should be acquired only when special reasons justify the upkeep and attention required." Forrester discussed how computing laboratories can be started and financed and the place that they should achieve in the university.

Short talks on applications of computing equipment were given by P. S. Dwyer (University of Michigan), H. R. J. Grosch (General Electric Company), J. O. Hirschfelder (University of Wisconsin), L. W. Kirchmayer (General Electric Company), H. G. Kolsky (Los Alamos Scientific Laboratory), H. W. Wolanski (Convair), and Marshall Rosenbluth (Los Alamos Scientific Laboratory). Two short addresses entitled "Computing in meteorology" and "Computing in astronomy" were given, respectively, by Philip Thompson (U.S. Air Force) and W. J. Eckert (International Business Machines Corporation).

The revolutionary effects of high-speed calculators, digital and analog, in scientific, engineering, industrial, and commercial and economic sciences were emphasized. The need for more basic research in the mathematics and applications was repeatedly stressed. Estimates of the demands for trained personnel in the future were somewhat staggering and will undoubtedly not be met.

The general addresses and talks on applications were followed by four panel discussions. The panel, "Future demands for trained personnel," was led by E. K. Ritter (Georgia Institute of Technology). Other panel members were Forman S. Acton (Princeton University), R. E. Gaskell (Boeing Aircraft), and Eldred Nelson (Ramo-Wooldridge Corporation). Future requirements for persons with training in numerical methods and machine computation were indicated. Gaskell said he was not in accord with the suggested need for a tremendous increase in trained people but that a much more moderate increase would be useful.

C. W. Adams (M.I.T. and Westinghouse Electric Corporation) led the panel discussion on curriculum needs. This panel was comprised of George R. Forsythe (University of California, Los Angeles), Vincent Rideout (University of Wisconsin), and David M. Young, Jr. (University of Maryland). Perhaps the principal lesson to be derived from this panel discussion was the lack of systematically developed course systems and the need for undergraduate instruction in numerical methods. Forsythe emphasized the need for thorough training in mathematics for doctoral candidates but said that no Ph.D. theses in numerical analysis have been written at UCLA! Numerical analysis has evidently not achieved respectability in the eyes of many mathematicians, despite its wealth of unsolved and meritorious problems.

John W. Carr, III (University of Michigan), led the panel, "Equipping a laboratory." Panel members were C. C. Gotlieb (University of Toronto), H. O. Hartley (Iowa State College), R. E. Meagher (University of Illinois), and Alan Perlis (Purdue University). Many interesting comparisons concerned the merits of building machines within the university, purchasing, and renting. It was pointed out that fully automatic high-speed calculators are needed to serve large universities, but that more modest equipment can serve the needs of undergraduate education.

The final panel, "Organization and financing," was led by J. P. Nash (University of Illinois). Members of the panel were H. H. Aiken (Harvard University), Arvid W. Jacobson (Wayne University), C. F. Kossack (Purdue University), R. J. Walker (Cornell University). Nash described the operation of the Illinois Digital Computing Laboratory. Aiken pointed out the need for recognition of the computing laboratory within the university organization to permit staff members the same scope permitted other professors. Aiken also suggested that industrial support of computing was likely to allow more freedom than government support.

Kossack described the organization and financial structure of the Statistical Research Laboratory at Purdue, giving explicitly costs and budget distribution. Walker described how Cornell has made a start recently with industrial support. In general, it was felt that education and research should be budgeted the same as other university departments and not made dependent on outside support. On the other hand, outside support is now solicited by all organizations represented on the panel and evidently yields about 50 percent of their total budgets.

The banquet address, "Dangerous gulfs," was given by J. H. Van Vleck (dean of the Applied Science Division at Harvard). In a unique approach to the evaluation of contributions to mankind's cultural attainments, Van Vleck vigorously upheld the importance of the role played by scientists and technologists.

The conference was sponsored by the Graduate Research Committee of the University of Wisconsin. Expenses were defrayed by Wisconsin Alumni Research Foundation funds. The University of Wisconsin Press is expected to publish the proceedings of the conference in book form.

PRESTON C. HAMMER
University of Wisconsin Numerical Analysis Laboratory, Madison

Meeting Notes

■ Recent progress in the study of aging and in understanding problems of the aged will be considered at the annual meeting of the Gerontological Society to be held at the Hotel Sheraton-Belvedere in Baltimore, Md., 27–29 Oct. Some 500

physicians, physiologists, biologists, chemists, sociologists, psychologists, social workers, and nurses are expected to attend the conference, at which more than 80 technical reports and other papers will be presented. All of the sessions will be open to the public.

The first of two general sessions is scheduled for the morning of 27 Oct. With Frederick D. Zeman of New York as chairman, it will be concerned with basic considerations on medical and social problems of aging and the aged. The second general session, on 28 Oct., will be chaired by Edward L. Bortz of Philadelphia and will be devoted to current research needs in the field. The four sections of the society—clinical medicine, biological sciences, psychological and social sciences, and social work and administration—will meet in simultaneous sessions each day of the meeting.

■ The Nuclear Engineering and Science Congress and the Atomic Exposition are to be held in Cleveland, Ohio, 12–16 Dec. The exposition, which will display everything from models of the atom to operating nuclear reactors, will open 10 Dec.

The congress, coordinated by the Engineers Joint Council, is being undertaken by the combined engineering and scientific societies of the nation, more than 25 of which are cooperating in the effort. Private firms and the Government are also actively supporting the congress. Nearly 300 papers describing the latest developments in nuclear engineering and science will be presented in technical sessions to the more than 2000 persons expected to attend.

Nuclear energy and its products are already used by more than 3000 industrial firms in the United States. This is but a small part of the potential application, as is demonstrated by the range of interest of participants in the congress. The sponsoring groups involve half a million engineers and scientists, representing such apparently diverse fields as mining, metallurgy, sanitation, water supply, radio, electronics, chemical, petroleum, steel, nonferrous metals, aviation, automobile manufacture, rockets, architecture, ships, road construction, and city planning.

Thorndike Saville, president of Engineers Joint Council and dean of engineering at New York University, summed up the primary purposes of the conference as follows: "The horizons for the peaceful application of atomic developments are, as yet, not even imagined. This highly interrelated family of developments is, as yet, very much in the 'idea for application' stage. Therefore, it is of enormous importance to present to those interested a panoramic view with detail as a proper measure of current opportunity and the vastness of potential. Progress for the conference already indicates that it will be the largest gathering of engineers and scientists ever held in the United States to discuss nuclear energy. As such, it will be a major opportunity for the communication of ideas and developments among the many thousands of persons in industry, business, agriculture and medicine, for whom the technology of the atom is increasingly important."

Basic objective of the congress is to launch a continuing program of interchange of information on the developing applications of nuclear science by the engineer and scientist for national benefits involving industry, agriculture, medicine, and the public welfare.

Announcement of the congress was made in January 1955 jointly by Saville; John R. Dunning, chairman of the Engineers Joint Council's general committee on nuclear engineering and science and dean of engineering at Columbia University; Donald L. Katz, chairman of the nuclear congress program committee and chairman of the chemical and metallurgical engineering departments of the

University of Michigan. The exposition to be held in connection with the congress was announced by Barnett F. Dodge of Yale University, president of the American Institute of Chemical Engineers, direct sponsor of the exposition.

■ The North Central Conference on Biology Teaching, held 19–30 Aug. at the University of Michigan Biological Station, Cheboygan, was sponsored by the National Association of Biology Teachers on a $15,000 grant from the National Science Foundation. Some 75 delegates from ten north central states considered teacher education and certification, teaching methods, and course content for improving biology teaching in colleges and secondary schools.

Important concepts were presented by the following: Robert Bowman of the University of Michigan, "Health and disease"; Samuel T. Dane, also of Michigan, "Conservation"; Harry Fuller of the University of Illinois, "Food supply of man"; Harold O. Goodman of Michigan State University, "Human genetics"; and John S. Karling of Purdue University, "Plants and man."

Published digests of these talks will supplement those of the five areas discussed at a similar meeting, the Southeastern Conference, that was held last year at the University of Florida; the latter covered taxonomy, physiology, genetics, ecology, and morphology. A report of the Florida conference was published as the January issue of the *American Biology Teacher*. A report of the Michigan conference will appear as the January 1956 issue of the same journal, which will be available from Paul V. Webster, Secretary-Treasurer of the NABT, Bryan High School, Bryan, Ohio.

The conference was directed by Richard L. Weaver of the University of Michigan, and a staff consisting of John Breukelman, Kansas State Teachers College; Paul Klinge, Howe High School, Indianapolis, Ind.; Richard Armacost, Purdue University; and Alfred Stockard, director of the University of Michigan Biological Station.

■ Many of the nation's encephalographers met 30 Sept. at the National Institutes of Health in Bethesda, Md., for the opening scientific session of a joint meeting of the Eastern Association of Electroencephalographers and the Southern Electroencephalographic Society. More than 100 members of these organizations assembled in the auditorium of the Clinical Center, where they were greeted by Cosimo Ajmone-Marsan, chief of the Electroencephalography Branch of the National Institute of Neurological Diseases and Blindness.

Presentation of a number of scientific papers was followed by lunch and a tour of the institute laboratories. In the afternoon, the members left for Skyland, Va., for the final 2 days of the meeting.

■ During the week of 29 Aug.–2 Sept. 1955, 44 persons from 17 different states and two foreign countries met at Fisk University, Nashville, Tenn., to participate in the university's 6th annual Infrared Spectroscopy Institute. The participants included 28 chemists, physicists, microbiologists, and biochemists; seven instrument engineers; and nine faculty and staff members.

Two lectures were given each morning, a laboratory session each afternoon, and a lecture each evening. The two introductory lectures were presented by Ernest A. Jones of Vanderbilt University, who discussed special techniques in infrared spectroscopy and applications to the study of the structure of simple molecules. James R. Lawson of Tennessee A and I State University lectured on qualitative analysis and on pressed potassium bromide disks for solid sampling. Alvin H. Nielsen of the University of Tennessee discussed the theoretical basis for molecular spectroscopy and recent ad-

vances in the field. Robert C. Gore of the American Cyanamid Co. placed infrared spectroscopy in its setting as an important technique for solving industrial problems. He also outlined the future of infrared spectroscopy in industrial research.

A. Lee Smith of the Dow-Corning Co. described the application of the potassium bromide pellet technique to the determination of metalorganic complexes and the use of infrared spectroscopy generally in the solution of problems in silicone chemistry. Nelson Fuson of Fisk University presented the results of research at Fisk on the infrared spectra of the methyl benzanthracenes, some of which are highly potent cancer-producing agents.

On the opening evening of the institute, Fuson reported on the 1955 meeting of European Molecular Spectroscopists at Oxford, England, from which he had just returned, and Nielsen showed colored slides and described the rigors of high-altitude infrared studies of the earth's atmosphere that used the sun as a source; he had conducted research on top of the Jung Frau Joch in Switzerland.

A standard and an advanced program were available during the afternoon laboratory sessions. Participants in the former program, besides receiving training in basic techniques, were introduced to five different types of commercial infrared spectrometers available for the laboratory sessions while they were on display at the institute. The advanced group was free to devote its time to particular fields.

Many participants brought compounds in order to make up potassium bromide pellet samples. A commercial infrared microscope attachment for a spectrometer was also of interest. In addition to the Fisk spectrometer, instruments were made available to the institute by the Perkin-Elmer Corp., Beckman Instruments, Inc., and the Will Corp. Participants also were permitted to use the double-beam spectrometers at Tennessee A and I State University and at Vanderbilt University.

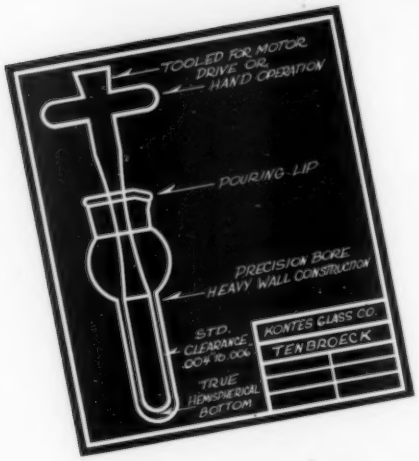
■ The centennial of engineering instruction at the University of Pennsylvania will be marked by a symposium on Modern Engineering that is to be held on 11 Nov. 1955 in the auditorium of the University Museum. The program includes the following speakers: Charles H. Weaver of the Westinghouse Electric Corporation; Granville M. Read of E. I. du Pont de Nemours and Company, Inc.; Elmer W. Engstrom of the Radio Corporation of America; Jay W. Forrester of Massachusetts Institute of Technology; and Ellis A. Johnson of the Army's Operations Research Office at Johns Hopkins University.

Gaylord P. Harnwell, president of the university, and a nuclear physicist, will greet those present. Cosponsoring the symposium are the Philadelphia sections of several national technical societies. All engineers are invited to attend.

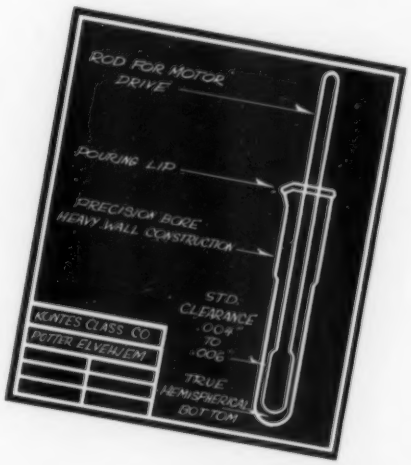
■ The International Union of Crystallography has accepted an invitation from the Consejo Superior de Investigaciones Científicas to hold a symposium next spring in Madrid. This symposium, which will take place 2–7 Apr. 1956, will be devoted to a consideration of "Solids exhibiting structure in the region between atomic and optical microscopic dimensions." It is intended to provide the opportunity for comparative discussions of results obtained by such different techniques as x-ray and electron diffraction, and electron microscopy.

The union's commissions on crystallographic apparatus and the teaching of crystallography will meet at the same time. They propose to have open sessions at which papers may be presented dealing with these two subjects. Particu-

Interchangeable TISSUE GRINDERS BY KONTES



POTTER-ELVEHJEM and TENBROECK TYPES



Are These Features Built Into Your Present Grinders?

- ***INTERCHANGEABILITY:*** Glass, Teflon* or Kel-F° pestles will fit one tube—maintaining standard clearances.
- ***FLEXIBILITY:*** Operation by hand or motor. Other than standard clearances are available on special order.
- ***DESIGN:*** True hemispherical bottom—Pouring lip—Heavy wall construction of precision bore tubing—Made of Pyrex glass.
- ***ECONOMY:*** Low initial cost. If damage occurs to one part, re-order that part only. Your replacement will fit the original part within standard clearances.

*Reg. T.M., E. I. duPont deNemours Co.
°Reg. T.M., M. W. Kellog Co.

FOR PROMPT SERVICE, RETURN COUPON TODAY

KONTES GLASS COMPANY
Vineland
New Jersey

Please send me literature on your Tissue Grinders

Name .....
Company .....
Street .....
City ..... Zone .... State .....

lar emphasis will be laid on new techniques bearing on the topic of the symposium.

Papers will be welcomed from persons who are not members of the commissions, and the attendance of all interested crystallographers and electron microscopists is invited. A special effort will be made to include papers and discussions that will appeal to the nonspecialist.

Titles of proposed communications, together with a brief summary of approximately 10 typewritten lines, should be sent to the president of the program committee, Prof. A. Guinier, Conservatoire National des Arts et Métiers, 292 Rue St. Martin, Paris (3), France, *before 1 Jan. 1956*. Those interested in the symposium and wishing to receive subsequent information about it should send their names and addresses as soon as possible to the Secretario del Comité del Symposium de la U. I. Cr., Serrano 118, Madrid, Spain.

Society Elections

■ Society for Social Responsibility in Science: pres., William T. Scott; v. pres., Edward G. Ramberg; sec., Elmer Goetz, Jr., 1319 Wakeling St., Philadelphia 24, Pa.; treas., Walter Gormly.

■ Botanical Society of America, Central States Section: chairman, Robert F. Thorne; v. chairman, Harriette Bartoo; sec.-treas., Howard R. Youse, DePauw University.

■ Society of Protozoologists: pres., L. R. Cleveland, Harvard University; v. pres., Willis H. Johnson, Wabash College; sec., Norman D. Levine, University of Illinois. Representative to the AAAS council is R. F. Nigrelli, New York Zoological Society.

■ Genetics Society of Canada: chairman, S. G. Smith, Forest Insect Laboratory, Sault Ste. Marie, Ontario; v. chairman, J. Unrau, University of Alberta; sec.-treas., L. P. V. Johnston, University of Alberta; eastern director, L. Chouinard, Laval University; western director, T. J. Arnason, University of Saskatchewan.

■ Phycological Society of America: pres., H. C. Bold, Vanderbilt University; v. pres., R. H. Thompson, University of Kansas; sec., P. C. Silva, University of Illinois; treas., R. C. Starr, Indiana University.

■ American Society of Plant Physiologists: pres., Harry A. Borthwick, U.S. Bureau of Plant Industry, Beltsville, Md.; v. pres., Aubrey W. Naylor, Duke University; sec., Arthur W. Galston, Yale University.

■ Astronomical League: pres., Grace C. Scholz, Alexandria, Va.; v. pres., Russell C. Maag, Sedalia, Mo.; sec., Joseph A. Anderer, Chicago; treas., Chandler H. Holton, Atlanta, Ga.; exec, sec., Wilma A. Cherup, 4 Klopfer St., Millvale, Pittsburgh 9, Pa.

Forthcoming Events

November

22–23. National Council of Geography Teachers, Indianapolis, Ind. (I. C. Robertson, State Teachers College, Valley City, N.D.)

22–25. International Cong. on Documentation of Applied Chemistry, 1st, London, Eng. (Cong. Committee, 56 Victoria St., London, S.W.1.)

25–26. American Mathematical Soc., Milwaukee, Wis. (E. G. Begle, Yale Univ., New Haven 11, Conn.)

25–26. American Physical Soc., Chicago, Ill. (K. K. Darrow, Columbia Univ., New York 27.)

25–26. American Soc. of Animal Production, annual, Chicago, Ill. (W. M. Beeson, Animal Husbandry Dept., Cornell Univ., Ithaca, N.Y.)

27–30. American Inst. of Chemical Engineers, Detroit, Mich. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

28–1. White House Conf. on Education, Washington, D.C. (C. Pace, Director; Comm. for White House Conf. on Education; South Health, Education and Welfare Bldg.; Washington 25.)

29–2. American Medical Assoc., clinical, Boston, Mass. (G. F. Lull, AMA, 535 N. Dearborn St., Chicago 10, Ill.)

29–2. Entomological Soc. of America, Cincinnati, Ohio. (R. H. Nelson, 1530 P St., NW, Washington 5.)

December

2. American Alpine Club, annual, New York, N.Y. (J. C. Oberlin, 909 Leader Bldg., Cleveland 14, Ohio.)

2–3. American Federation for Clinical Research, Eastern, Philadelphia, Pa. (C. R. Shuman, Temple Univ. Hospital, Broad and Ontario Sts., Philadelphia 40, Pa.)

2–3. Oklahoma Acad. of Science, Norman. (D. E. Howell, Dept. of Entomology, Oklahoma A. & M. College, Stillwater.)

2–4. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, 36 W. 44 St., New York 36.)

4. American Acad. of Dental Medicine, 10th mid-annual, New York, N.Y. (G. J. Witkin, 45 South Broadway, Yonkers 2, N.Y.)

8–10. Florida Acad. of Sciences, Miami. (R. A. Edwards, Geology Dept., Univ. of Florida, Gainesville.)

9–10. Assoc. for Research in Nervous and Mental Disease, 35th annual, New York, N.Y. (C. C. Hare, 710 W. 168 St., New York 32.)

9–10. Texas Acad. of Science, annual, Waco. (G. P. Parker, P.O. Box 7488, College Station, Texas.)

9–13. American Acad. of Optometry, Chicago, Ill. (C. C. Koch, 1502 Foshay Tower, Minneapolis 2, Minn.)

10–16. Nuclear Cong. and Atomic Exposition, Cleveland, Ohio. (A. F. Denham, 931 Book Bldg., Detroit 26, Mich.)

10–16. Radiological Soc. of North America, Inc., Chicago, Ill. (D. S. Childs, Sr., 713 E. Genesee St., Syracuse 2, N.Y.)

11–14. American Soc. of Agricultural Engineers, Chicago, Ill. (F. B. Lanham, ASAE, St. Joseph, Mich.)

11–14. American Soc. of Refrigerating Engineers, New York, N.Y. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

15–17. Acoustical Soc. of America, Providence, R.I. (W. Waterfall, ASA, 57 E. 55 St., New York 22.)

15–17. International Union of Scientific Radio, U.S. national, Gainesville, Fla. (J. P. Hagen, Code 7100, URSI, Naval Research Lab., Washington 25.)

16–21. Interamerican Cong. of Psychology, 3rd, Austin, Tex. (W. Holtzman, Univ. of Texas, Austin.)

26–29. Biometric Soc., Eastern N. American Region, New York, N.Y. (A. M. Dutton, Box 287, Station 3, Rochester 20, N.Y.)

26–31. American Assoc. for the Advancement of Science, Atlanta, Ga. (R. L. Taylor, AAAS, 1025 Connecticut Ave., NW, Washington 6.)

The following 32 meetings will be held in conjunction with the AAAS annual meeting.

26–27. American Assoc. of Clinical Chemists, Atlanta, Ga. (A. E. Sobel, Dept. of Biochemistry, Jewish Hospital of Brooklyn, 555 Prospect Pl., Brooklyn 16, N.Y.)

26–30. American Nature Study Soc., Atlanta, Ga. (M. Trussell, School of Education, Florida State Univ., Tallahassee.)

26–30. National Assoc. of Biology Teachers, Atlanta, Ga. (J. P. Harrold, 110 E. Hines St., Midland, Mich.)

27. National Assoc. of Science Writers, Atlanta, Ga. (O. Fanning, Midwest Research Inst., Kansas City, Mo.)

27. National Speleological Soc., Atlanta, Ga. (Bro. G. Nicholas, F.S.C., 114 Hanover St., Cumberland, Md.)

27. Soc. for Research in Child Development, Atlanta, Ga. (W. C. Rhodes, Georgia Dept. of Public Health, Atlanta.)

27–28. American Psychiatric Assoc., Atlanta, Ga. (H. E. Himwich, Research Div., Galesburg State Research Hospital, Galesburg, Ill.)

27–28. Soc. for the Advancement of General Systems Theory, Atlanta, Ga. (L. von Bertalanffy, Center for Advanced Study in the Behavioral Sciences, Menlo Park, Calif.)

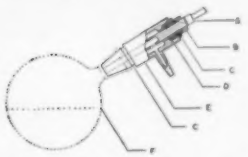
27–29. American Geophysical Union, Atlanta, Ga. (W. Smith, 1530 P St., NW, Washington 5.)

27–29. American Meteorological Soc., Atlanta, Ga. (K. Spengler, 3 Joy St., Boston, Mass.)

27–29. Assoc. of Southeastern Biologists, Atlanta, Ga. (M. E. Gaulden, Biology Div., Oak Ridge National Lab., Oak Ridge, Tenn.)

27–29. International Geophysical Year, Atlanta, Ga. (H. Odishaw, National Research Council, Washington 25.)

Rinco
Rotating
Vacuum-Type Evaporator



For rapid evaporation of solvents of low volatility
Will speed evaporation rates from four to five times

Adaptable for volumes of 1 ml to 500 ml. Can be used in single or multiple units. It is especially advantageous with solvents such as water, dimethylformamide, etc.; e.g., at 20°C 30 ml of water will be evaporated in 30 minutes. Although especially useful with biological extracts or heat sensitive compounds, as no temperature increases are necessary, the instrument will, of course, operate satisfactorily at higher evaporation rates with increased temperature, where characteristics of sample permit. Consists of stainless steel shaft with a ST 19/38 at the lower end. Shaft rotates on oilite bronze bearings within a stainless steel housing having a ST 12/30 take-off leading to a pump. Although the instrument can be used with a standard aspirator, a standard pump and trap are recommended for superior results. Flasks held with the ST joint at end of shaft are rotated at 56 r.p.m. by means of a special motor. Provided with a ST 19/38 joint to accommodate smaller capacity flasks; e.g., 50 ml. With the addition of No. L80820D "Pyrex" brand adapter, the instrument will handle larger flasks having a ST 24/40 joint. For use on 110-115 volts, 60 cycle, A.C. Complete with motor, cord, ST 19/38 joint, but without No. L80820D, ST 20/40-19/38 adapter. Key to Sketch: (A) Stainless steel shaft with machined ST 19/38 joint at lower end. (B) Collar, with set screw. (C) Oilite bronze bearings. (D) ½-inch I.D. neoprene "O" ring(s). (E) Stainless steel housing equipped with ST 12/30 take-off for pump. (F) Flask.

L39474—Rinco Rotating Vacuum-type Evaporator, each $96.50

L80820D—Adapter—"Pyrex" Brand, for adapting ST 19/38 joint of Rinco Evaporator to larger flasks, each.....$ 1.70

ALOE SCIENTIFIC DIVISION OF A. S. ALOE COMPANY
5655 Kingsbury, St. Louis 12, Mo.

LOS ANGELES SAN FRANCISCO SEATTLE MINNEAPOLIS KANSAS CITY
DALLAS NEW ORLEANS ATLANTA WASHINGTON, D. C.

27–29. Oak Ridge Inst. of Nuclear Studies, Atlanta, Ga. (C. L. Comar, ORINS, Oak Ridge, Tenn.)

27, 29. Soc. of the Sigma Xi, Atlanta, Ga. (T. T. Holme, 56 Hillhouse Ave., New Haven, Conn.)

27–30. American Phytopathological Soc., Atlanta, Ga. (G. S. Pound, Dept. of Plant Pathology, Univ. of Wisconsin, Madison.)

27–30. American Soc. of Parasitologists, Atlanta, Ga. (A. C. Walton, Dept. of Biology, Knox College, Galesburg, Ill.)

27–30. Botanical Soc. of America, Southeastern Section, Atlanta, Ga. (F. T. Wolf, Dept. of Biology, Vanderbilt Univ., Nashville 5, Tenn.)

27–30. Ecological Soc. of America, Atlanta, Ga. (R. B. Platt, Dept. of Biology, Emory Univ., Emory University, Ga.)

27–30. National Science Teachers Assoc., Atlanta, Ga. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington 6.)

27–30. Soc. of Systematic Zoology, Atlanta, Ga. (D. C. Scott, Dept. of Zoology, Univ. of Georgia, Athens.)

28. Alpha Epsilon Delta, Atlanta, Ga. (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.)

28. National Assoc. for Research in Science Teaching, Atlanta, Ga. (G. G. Mallinson, Western Michigan College of Education, Kalamazoo.)

28. Sigma Pi Sigma, Atlanta, Ga. (M. W. White, Physics Dept., Pennsylvania State Univ., University Park.)

28. Soc. of General Physiologists, Atlanta, Ga. (J. Buck, National Institutes of Health, Bethesda 14, Md.)

28–2′. American Soc. of Naturalists, Atlanta, Ga. (W. P. Spencer, Dept. of Genetics, Univ. of Texas, Austin 12.)

28–29. Herpetologists League, Atlanta, Ga. (J. A. Fowler, Acad. of Natural Sciences, 19th and Parkway, Philadelphia 3, Pa.)

29. American Assoc. of Hospital Consultants, Atlanta, Ga. (J. Masur, Asst. Surgeon-General, USPHS, Washington 25.)

29. National Acad. of Economics and Political Science, Atlanta, Ga. (D. P. Ray, Hall of Government, George Washington Univ., Washington, D.C.)

29. National Geographic Soc., Atlanta, Ga. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6.)

29. Scientific Research Soc. of America, Atlanta, Ga. (D. B. Prentice, 54 Hillhouse Ave., New Haven, Conn.)

30. American Soc. of Plant Physiologists, Southern Section, Atlanta, Ga. (A. W. Naylor, Duke Univ., Durham, N.C.)

30. United Chapters of Phi Beta Kappa, Atlanta, Ga. (C. Billman, 1811 Q St., NW, Washington, D.C.)

27–29. American Mathematical Soc., 62nd annual, Houston, Tex. (J. H. Curtiss, AMS, 80 Waterman St., Providence 6, R.I.)

27–29. Archaeological Inst. of America, Chicago, Ill. (C. Boulter, 608, Univ. of Cincinnati Library, Cincinnati 21, Ohio.)

27–29. Assoc. for Symbolic Logic, Rochester, N.Y. (J. Barlaz, Rutgers Univ., New Brunswick, N.J.)

27–29. Linguistic Soc. of America, Chicago, Ill. (A. A. Hill, 1719 Massachusetts Ave., NW, Washington 6.)

27–29. Western Soc. of Naturalists, Davis, Calif. (D. Davenport, Univ. of California, Santa Barbara.)

27–30. American Statistical Assoc., New York, N.Y. (E. M. Bisgyer, 1757 K St., NW, Washington 6.)

27–30. Inst. of Mathematical Statistics, New York, N.Y. (K. J. Arnold, Dept. of Mathematics, Michigan State Univ., East Lansing.)

27–1. Phi Delta Kappa, 50th anniversary, Bloomington, Ind. (J. C. Whinnery, 324 N. Greenwood Ave., Montebello, Calif.)

28–29. Northwest Scientific Assoc., Spokane, Wash. (F. J. Schadegg, Eastern Washington College of Education, Cheney.)

28–30. American Economic Assoc., New York, N.Y. (J. W. Bell, Northwestern Univ., Evanston, Ill.)

28–30. American Historical Assoc., Washington, D.C. (B. C. Shafer, Study Room 274, Library of Congress Annex, Washington 25.)

28–30. American Philological Assoc., Chicago, Ill. (J. P. MacKendrick, Bascom Hall, Univ. of Wisconsin, Madison 6.)

28–30. American Philosophical Assoc., Eastern Div., Boston, Mass. (W. H. Hay, Dept. of Philosophy, Univ. of Wisconsin, Madison.)

28–30. American Physical Soc., winter meeting, Los Angeles, Calif. (K. K. Darrow, Columbia Univ., New York 27.)

28–30. Econometric Soc., New York, N.Y. (R. Ruggles, Box 1264, Yale Station, Yale Univ., New Haven, Conn.)

29. Metric Assoc., Inc., annual, Washington, D.C. (V. G. Shinkle, 1916 Eye St., NW, Washington 6.)

29–30. American Folklore Soc., Washington, D.C. (M. Leach, Bennett Hall, Univ. of Pennsylvania, Philadelphia 4.)

29–30. History of Science Soc., Washington, D.C. (T. S. Kuhn, 74 Buckingham St., Cambridge 38, Mass.)

30. Mathematical Assoc. of America, 39th annual, Houston, Tex. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

January

9–10. Operations Research Soc. of America, 8th national, Ottawa, Ont., Canada. (J. Abrams, Dept. of National Defense, Ottawa.)

9–14. Pan American Cong. of Ophthalmology, 5th, Santiago, Chile. (T. D. Allen, 575 Lincoln St., Winnetka, Ill.)

10. American Ethnological Soc., New York, N. Y. (A. G. James, 695 Park Ave., New York 21.)

12. American Genetic Assoc., Washington, D.C. (S. L. Emsweller, Plant Industry Sta., Beltsville, Md.)

12–14. Use of Isotopes in Agriculture, East Lansing, Mich. (E. W. Phelan, Argonne National Lab., Box 299, Lemont, Ill.)

16–18. Documentation Conf., Cleveland, Ohio. (J. H. Shera, School of Library Science, Western Reserve Univ., Cleveland 6.)

17–20. American Pomological Soc., Rochester, N.Y. (R. B. Tukey, Horticulture Dept., Purdue Univ., Lafayette, Ind.)

20–27. Pan American Cong. of Gastro-Enterology, 5th, Havana, Cuba. (N. M. Stapler, 1267 J. E. Uriburu, Buenos Aires, Argentina.)

23–26. American Soc. of Heating and Air-Conditioning Engineers, Cincinnati, Ohio. (A. V. Hutchinson, ASHAE, 62 Worth St., New York 13.)

23–27. Inst. of Aeronautical Sciences, New York, N.Y. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

30–3. American Inst. of Electrical Engineers, New York, N.Y. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

31–4. American Physical Soc., New York, N.Y. (K. K. Darrow, Columbia Univ., New York 27.)

February

5–8. National Citizens' Planning Conf., Washington, D.C. (Miss H. James, 901 Union Trust Bldg., Washington 5.)

9–10. Soc. of American Military Engineers, annual, Chicago, Ill. (D. A. Sullivan, 72 W. Adams St., Chicago 90.)

19–23. American Inst. of Mining and Metallurgical Engineers, New York, N.Y. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

Equipment News

■ GAS DENSITY BALANCE measures the density of a sample gas by a null balance principle. A small dumbbell is supported on a horizontal quartz fiber. One ball of the dumbbell is punctured so that it will not experience buoyancy effects. The other ball tends to change position as the density of the gas changes, creating a rotational force about the quartz fiber that is proportional to the density of the gas. The dumbbell is metal coated and is held in place by an electrostatic force that is established by adjacent electrodes. When the dumbbell rotates, it is restored to its null position by the application of a balancing potential to the electrodes. The balancing potential, which is also proportional to the density of the gas, may be used to operate a meter or recorder. Sensitivity and accuracy are each 0.5 percent of full scale; a 95-percent response is obtained in less than 1 min. Bulletin 118. (Arnold O. Beckman, Inc., Dept. Sci., 1020 Mission St., South Pasadena, Calif.)

■ GEIGER COUNTER Halotron "15" is a portable 15-tube unit that is designed for use in detecting uranium ore and for general survey work. According to the manufacturer, the unit's sensitivity is greater than that of many geiger counters and its performance is comparable to that of some scintillation counters. The unit, which is waterproof and shockproof, is powered by two standard "D" flashlight cells and three miniature "B" batteries; its dimensions are 3¼ by 8 by 7⅞ in. and its weight is approximately 5 lb. Cover and case are made of drawn aluminum; interior metal parts are cadmium plated. (Nuclear Measurements Corp., Dept. Sci., 2460 N. Arlington Ave., Indianapolis 18, Ind.)

■ DIRECT-CURRENT AMPLIFIER has push-pull input and output circuits with input impedance of 100 Mohm and grid current of 10^{-2} μa, band pass flat to 50 kcy/sec, and four bandwidths that may be selected from the front panel. Sensitivity may be varied by means of a calibrated attenuator with a maximum gain of 100 db. Drift obtainable is 5 μv/min or less. In-phase signal rejection is adjustable to 50,000 to 1. Noise level is 10 μv root-mean-square at full bandwidth. (American Electronic Laboratories, Inc., Dept. Sci., 641 Arch St., Philadelphia 6, Pa.)

■ DIRECTIONAL SCINTILLATION COUNTER, heavily shielded for maximum directionality, is supplied with a 1- by 1-in. sodium iodide crystal. When the removable forward shield is in place, a ratio of at least 50 to 1 is obtained between count rates from an I^{131} source within the acceptance cone and one outside the cone at the same distance from the crystal. The angle of sensitivity may be varied by changing the threaded lead collimator in the nose of the shield. The new counter includes a photomultiplier that has been chosen for good signal-to-noise characteristics. It is supplied with cable for connection to any scaler or rate meter. (NRD Instrument Co., Dept. Sci., 6429 Etzel Ave., St. Louis 14, Mo.)

■ PORTABLE REFRIGERATION SYSTEM provides means for cooling a vessel or cabinet from ambient temperature to 0°F. The unit has a mobile 5 by 8-in. copper cooling coil, adjustable thermostatic control, 8-ft insulated hose, air-cooled compressor, and Freon 12 refrigerant. It operates on 115-v alternating current. Cooling capacity is 790 Btu/hr. (A. Daigger and Co., Dept. Sci., Kinzie at Wells, Chicago 10, Ill.)

■ LIQUID SCINTILLATION SPECTROMETER is designed for precise counting of beta samples in solution with liquid phosphors. Isotopes with low beta energies, such as tritium, carbon-14, sulfur-35, and calcium-45, can be counted either individually or in mixtures. The photomultipliers are shielded from room light at all times, and it is not necessary to manipulate samples in the dark. (Packard Instrument Co., Dept. Sci., P.O. Box 428, Lagrange, Ill.)

■ ACCESSORY SLOT COMPENSATOR that can be attached to most standard microscopes is intended to aid in the identification of minerals and chemicals. Compensator is used to measure birefringence; readings are then obtained from determination charts. Determinations correct to ± 2 percent without calibration are read directly in millimicrons from a scale engraved on a rotatable drum; computations and conversion tables are not necessary. The instrument performs with greatest efficiency when light of wavelength 5890 A is used; an interference filter is available for use with tungsten illuminators. Retardations from 0 to 2700 mμ can be measured. (Bausch and Lomb Optical Co., Dept. Sci., Rochester, N.Y.)

new giant

5-Quart BLENDOR

MIXES — BEATS — BLENDS
PULPS — PULVERIZES
MASCERATES — EMULSIFIES

Here's the famous Waring Blendor in a new large size designed for pilot or production batches. Its five operating speeds range from 8,000 to 16,000 rpm and are operated with push-button control. This new model has a stainless steel container and the zinc die-cast base, finished in gray and white enamel, is designed for fastening permanently to a working surface.

Heavy duty motor. Extra powerful . . . 1½ HP . . . for high efficiency blending.

Two section cover. Made with easy-to-use snap-on latches and removable plexi-glass section for sampling and adding.

Insto-matic speed control. Quickly change from low to high speeds and reverse without stopping, with 6 push button control.

Stainless steel container—easy-pour handle. Made of durable stainless steel in patented clover leaf pattern with easy-pour handle.

Removable blade assembly. Easily assembled with hand-tightened nut for quick removal and cleaning.

Self lubricating. Never requires greasing or oiling. Sealed-in lubrication gives smooth lifetime operation.

This large capacity Blendor lends itself to almost unlimited applications in laboratory or plant. Order today or write for our Bulletin No. 1241 containing full details.

Cenco
No. 17220
BLENDOR
each, **$275.00**

cenco
The most complete line of scientific instruments and laboratory supplies in the world
S.S.C.

CENTRAL SCIENTIFIC COMPANY
MAIN OFFICE — PLANT — CENCO INTERNATIONAL CIA.
1718-M IRVING PARK ROAD • CHICAGO 13, ILLINOIS
BRANCHES AND OFFICES — CHICAGO NEWARK BOSTON WASHINGTON DETROIT SAN FRANCISCO SANTA CLARA LOS ANGELES
CENTRAL SCIENTIFIC CO. OF CANADA, LTD. (and Hendry Division) TORONTO MONTREAL VANCOUVER OTTAWA
REFINERY SUPPLY COMPANY — TULSA HOUSTON

■ FLAME PHOTOMETER model 146, which has been announced by Perkin-Elmer, has a stainless steel burner and a simplified atomizer. The unit will operate on natural, city, propane, or acetylene gas. The new atomizer uses a straight-through capillary. There is a ground glass joint between the atomizer and the atomizer chamber. Excess solution in the stream is drained through a fitted glass filter. The funnel has a flow rate of 4 to 6 ml/min. As little as 2 ml of sample is required to obtain a reading. Accuracy of ± 2 percent is possible on routine sodium and potassium analysis; accuracy is ± 1 percent by internal-standard measurements. Alkaline earths may be analyzed. The dimensions of the metal cabinet are 21⅜ by 13¼ by 18¼ in. The sloping front panel is made of Fiberglas. (Perkin-Elmer Corp., Dept. Sci., Norwalk, Conn.)

■ FRACTION COLLECTOR for chromatography makes collections automatically by either the timed-flow or the volumetric method. Since support is furnished at the bottom of the tubes, both culture and lipped tubes may be used for collection. Three interchangeable receiver tables, which are equipped with mounting holes for an indexer, are available. An electronic timer-controller that is capable of indexing each tube to receive fractions on a timed-flow basis from 18 sec to 2 hr is also available. The instrument is designed so that neither mercury, chemicals, nor electric current come into contact with the sample. (Schaar and Co., Dept. Sci., 754 W. Lexington St., Chicago 7, Ill.)

■ OPTICAL DESIGN KIT for engineers has 19 components, including a prism; cylindrical and spherical lenses; and flat, cylindrical, and spherical mirrors suitable for use in optical systems and devices. (Houston Technical Laboratories, Dept. Sci., 2424 Branard, Houston 6, Tex.)

■ INFRARED DETECTORS have sensitive elements made of 10-μ-thick rectangular flakes of thermistor material. Dimensions of each element can be varied from 0.1 to 10.0 mm. A shielded compensating element minimizes the effects of ambient temperature changes. Housings are hermetically sealed and do not require a vacuum. (Barnes Engineering Co., Dept. Sci., 30 Commerce Rd., Stamford, Conn.)

■ AUTOMATIC SEPARATORY FUNNEL, the VirTis Extracto-Matic, consists of a stainless-steel box-type stand that houses a heavy-duty electric motor. Motor drives a rocker arm to which eight specially designed Pyrex separatory funnels are clamped. Rocker arm swings up and down through a 90° arc at a rate of 20 oscillations per minute. The separatory funnels do not require stoppers, for the fluid openings always remain above the solution level. Solution is inserted when the separatory funnels are in the horizontal position; fluid can be drained through a precision-ground stopcock when the funnels are in the vertical position. (E. Machlett and Son, Dept. Sci., 220 E. 23 St., New York 10)

■ GRAPHIC RECORDER model G-10, a portable unit that measures 10 by 7⅛ by 8 in., has been announced by Varian Associates. The instrument is of the self-balancing potentiometer type. Full-scale response is 2.5 sec; sensitivity is 100 mv full-scale; accuracy is 1 percent; maximum allowable signal source resistance

is 0.5 Mohm. The recorder is designed to be used directly as a recording millivoltmeter or, with appropriate transducers, as a means for recording pressure, light intensity, and temperature (Varian Associates, Dept. Sci., 611 Hansen Way, Palo Alto, Calif.)

■ DISPERSION MILL, a laboratory model of the Kady industrial dispersion mill, has been made available. The capacity of the new model is 1/3 to ½ gal, and all working parts are made of stainless steel. The mill occupies 25½ by 15¼ in. of bench space and requires less than 30 in. of head room, including space for the operation of the hydraulic lift. It is driven by a 1-hp, three-phase, 220- or 440-v motor. (Kinetic Dispersion Corp., Dept. Sci., 95 Botsford Pl., Buffalo 16, N.Y.)

■ RESISTANCE THERMOMETER measures the change, with temperature, in the electric resistance of 50 in. of 0.002-in. diameter, spun-glass-insulated, high-purity nickel wire. The scale, which is graduated from −100°C to +276°C in 0.5°C and 1.0°F divisions, is printed on an 89-in. roll of Cronar film. Accuracy from −100°C to +250°C is ±0.5°C; above 250°C it is ±1.0°C. (Fisher Scientific Co., Dept. Sci., 717 Forbes St., Pittsburgh 19, Pa.)

■ MICROMANIPULATOR designed and developed by H. H. Hillemann of Oregon State College can be used to produce rapid or slow movement in a straight line as well as a movement of up to 2 in. in each of the mutually vertical planes. Instrument can be attached to either side of any microscope. Adjustment of the stage of the micromanipulator may be required. (Custom Scientific Instruments, Inc., 541 Devon St., Dept. Sci., Kearny, N.J.)

■ VISCOSIMETER designed to satisfy the equation $V_a = 0.04t - 8/t$ consists of a metal stand that supports an orifice cup over a receiver cup. Both cups are disposable. Orifice cup is marked with a fill line; receiver cup is also marked with a line; time required to fill the receiver cup to the line must be measured with a separate stop watch. Errors resulting from cup variation are less than ±5 percent. (Gardner Laboratory, Inc., Dept. Sci., Bethesda 14, Md.)

■ INVERTED SPECTROGRAPH designed so that the x-ray beam strikes specimens from the bottom may be used for analysis of metals, powders, and liquids. Three specimen holders fit into a horizontal disk that rotates inside a leaded-bronze housing. Disk shaft extends through the top of the housing to a control knob. Specimen holders have ¼-mil thick

Mylar windows that are held in place with retaining rings. A nickel-foil collimator with ⅛-in. spacing is built into the instrument. (Research and Control Instruments Div., North American Philips Co., Inc., Dept. Sci., 750 S. Fulton Ave., Mount Vernon, N.Y.)

■ COLD CATHODE COUNTING TUBE type GS12D has 12 cathodes brought out to pins on the 13-pin base. Positive voltage is available on the glowing cathode. Counting rate is 0 to 4000 pulses/sec. Tube is 3.49 in. long, bulb diameter is 1.3 in., and base diameter is 1.39 in. Anode current is 0.35 ma maximum; supply voltage is 350 v; and maximum voltage between electrodes, other than anode, is 140 v. (Atomic Instrument Co., Dept. Sci., 84 Massachusetts Ave., Cambridge 39, Mass.)

■ PRECISION RESISTANCE METER type RGV has an over-all range of 0.01 ohm to 100 Mohm broken down into seven individual ranges. Accuracy is ± 0.1 percent ± 1 mohm in the ranges from 0.01 ohm to 10 Mohm and ± 0.5 percent in the range from 10 to 100 Mohm. Load on the unknown is less than 10 mw. (Instrument Div., Federal Telephone and Radio Co., Dept. Sci., 100 Kingsland Rd., Clifton, N.J.)

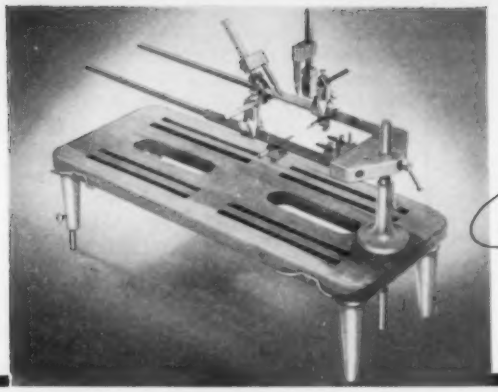
■ VARIABLE-SPEED ROTATOR for serological tests operates at constant speed for any setting within its range of 100 to 220 rev/min. Operating speed, which is maintained by an electric governor, is reproducible. Timed operation from 0 to 30 min is provided. Slides are held by a sponge-rubber pad cemented to a 13- by 13-in. platform. Every point on the surface of the platform rotates through a uniform ¾-in. diameter circle. Bulletin 210. (Eberbach Corp., Dept. Sci., Ann Arbor, Mich.)

■ CONSTANT-TEMPERATURE BATH for storage and processing of bottled solutions at temperatures up to 60°C has a built-in centrifugal pump circulator that provides temperature control of ± 0.1°C. Bath, which measures 5 by 5 by 3 ft, holds bottles in 16 individual wire baskets. The two-piece cover is counterbalanced. Bulletin SK-109. (Labline, Inc., Special Products Div., Dept. Sci., 3070-82 W. Grand Ave., Chicago 22, Ill.)

■ MICROWAVE FREQUENCY STANDARD accurate to ± 0.001 percent for the frequency range of 2400 to 40,000 Mcy/sec consists of a temperature-stabilized crystal oscillator followed by a multiplier-amplifier chain with outputs at 100, 500, and 1500 Mcy/sec. The standard is supplied with sweep circuits for use with reflex klystron local oscillators. Wave guide units for specified frequency ranges include a harmonic mixer that has been designed specifically for multiplying a crystal-controlled signal, frequency meter, directional coupler, two variable pads, termination, detector, and coaxial adapter. (Narda Corp., Dept. Sci., Mineola, N.Y.)

■ RESEARCH DEMINERALIZER OF ion-exchange kit consists of two Lucite ion-exchange columns, five jars of cation resins, seven jars of anion resins, a 100-page manual of technical data on the resins, and instructions for operating the device as a mixed- or two-bed ion exchanger. (Barnstead Still and Sterilizer Co., Dept. Sci., 256 Lanesville Terr., Forest Hills, Boston 31, Mass.)

■ GLASSWORKING EQUIPMENT CATALOG describes Lab-Lathe, a general-purpose glassworking machine, and its accessories, together with other glassworking equipment. Section 2 of the catalog is devoted to mercury, mercury cleaning apparatus, and a mercury vapor detector. Technical articles on the Lab-Lathe and on mercury are included. Catalog 54. (Bethlehem Apparatus Co., Inc., Dept. Sci., Hellertown, Pa.)



APPARATUS FOR RESEARCH

STEREOTAXIC INSTRUMENTS

TOP: Stereotaxic Instrument mounted on adjustable hardwood stand No. G-109, and showing one application of extension bars with 2 electrode carriers. Rigidity of instrument is an important feature for precision work.

MIDDLE: Unmounted instrument showing simplicity of design for stability, accuracy, ready interchangeability of parts and ease of assembly. Accurately calibrated movements allow flexibility of approach.

BOTTOM: Complete instrument in walnut carrying case. Space is provided for future purchase of additional attachments.

The Accepted Standard in the Research Field for Neurophysiology

Here is a modern instrument for research on cats, monkeys and rats, used in the co-ordinate placement of Pickup, Stimulating and Coagulating electrodes in brain and spinal cord. It is precision designed and constructed of corrosion resistant materials not affected by cold or steam sterilization. Built to allow complete flexibility of approach and calibrated for extreme accuracy. The unobstructed position of head of subject in instrument provides broad operative field in surgery. A Stereotaxic Instrument is also available for research on humans.

LAB-TRONICS, INC. is an organization of internationally known medical and engineering research scientists dedicated to the development, design, and manufacture of precision apparatus for research in such scientific fields as Physiology, Neurology, Histology, Biochemistry, Pathology, Neurosurgery, Physical-Chemistry and Biophysics, and employing the most advanced techniques in electronics and engineerings.

SEND FOR BULLETIN NO. 5

LAB-TRONICS INCORPORATED

1115 W. WASHINGTON BLVD. — CHICAGO 7, ILLINOIS

Index of Advertised Products

Classified below are the products advertised in *Science* in the issues from 29 Oct. 1954 through 21 Oct. 1955. Dates and page numbers are given except for advertisements that appeared regularly every week or two throughout the year. At the end of the classified index is a list of companies that advertised in "The Market Place" section during the period 29 Oct. 1954 through 21 Oct. 1955.

Technicon Chromatography Corp.
1954: 31 Dec., 2C
1955: 12 Aug., 266
Welch, W. M., Manufacturing Co.
1954: 10 Dec., 8A
1955: 6 May, 8A; 26 Aug., 358

CLEANSERS

Alconox, Inc.
1955: 28 Jan., 2A; 16 Sept., 495; 21 Oct., 773
Hospital Liquids, Inc.
1954: 5 Nov., 6A; 3 Dec., 14A
1955: 7 Jan., 2A
Linbro Chemical Co.
1954: 29 Oct., 9A; 19 Nov., 10A; 3 Dec., 8A
1955: 11 Feb., 10A; 4 Mar., 2A; 1 Apr., 11A; 6 May, 11A; 21 Oct., 802
Meinecke & Co., Inc.
1954: 12 Nov., 3A; 3 Dec., 24A
1955: 7 Jan., 18A; 11 Feb., 13A; 15 Apr., 14A; 13 May, 12A; 10 June, 12A; 19 Aug., 345
Standard Scientific Supply Corp.
1954: 5 Nov., 3C; 3 Dec., 9A
1955: 21 Jan., 2C; 25 Mar., 7A

COLORIMETER

Biddle, James G., Co.
1955: 29 July, 180
Thomas, Arthur H., Co.
1954: 5 Nov., 4C; 3 Dec., 4C

COULOMETERS

C. A. Brinkmann & Co.
1955: 9 Sept., 481

DENSITOMETER

Photovolt Corp.
1954: 29 Oct., 3A; 12 Nov., 4A; 26 Nov., 3A; 17 Dec., 2A; 24 Dec., 5A
1955: 7 Jan., 4A; 21 Jan., 6A; 4 Feb., 5A; 18 Feb., 8A; 4 Mar., 6A; 18 Mar., 8A; 1 Apr., 3C; 15 Apr., 8A; 29 Apr., 3A; 6 May, 11A; 20 May, 2A; 3 June, 5A; 24 June, 2A; 8 July, 89; 29 July, 211; 12 Aug., 299; 9 Sept., 486; 23 Sept., 574; 7 Oct., 662; 14 Oct., 670
Welch, W. M., Manufacturing Co.
1954: 10 Dec., 8A
1955: 4 Feb., 9A; 25 Feb., 6A; 6 May, 8A; 26 Aug., 358

DESICCATORS

Phipps & Bird, Inc.
1955: 15 July, 104; 9 Sept., 452; 23 Sept., 575; 7 Oct., 622

DUST–SAMPLING APPARATUS

Ficklen, Joseph B., III
1954: 3 Dec., 8A
1955: 14 Jan., 8A; 25 Feb., 4A; 8 Apr., 2A; 20 May, 11A; 1 July, 43; 12 Aug., 299; 23 Sept., 571

ELECTROENCEPHALOGRAPHS

Electro-Medical Laboratory, Inc.
1954: 29 Oct., 2A; 26 Nov., 4A; 24 Dec., 2A
1955: 21 Jan., 10A; 1 Apr., 11A; 29 Apr., 4A; 27 May, 13A; 24 June, 2A; 22 July, 174; 19 Aug., 345; 16 Sept., 534; 14 Oct., 704

ELECTRONIC TESTING EQUIPMENT

Hycon Electronics, Inc.
1955: 21 Oct., 724

ELECTROPHORESIS APPARATUS

Beckman Instruments, Inc., Spinco Div.
1955: 10 June, 3C; 24 June, 3A; 19 Aug., 308; 21 Oct., 737
Brinkmann, C. A., & Co.
1955: 16 Sept., 527; 14 Oct., 668
Klett Manufacturing Co.
1954: 29 Oct., 12A; 12 Nov., 2A; 26 Nov., 9A; 3 Dec., 2A; 10 Dec., 4A; 24 Dec., 3C
1955: 7 Jan., 12A; 4 Feb., 6A; 18 Feb., 12A; 4 Mar., 14A; 18 Mar., 4A; 1 Apr., 6A; 15 Apr., 2A; 29 Apr., 3C; 13 May, 17A; 27 May, 4A; 10 June, 6A; 24 June, 4A; 8 July, 91; 22 July, 142; 5 Aug., 220; 19 Aug., 345; 2 Sept., 435; 16 Sept., 530; 30 Sept., 611; 14 Oct., 710
Long Island Surgical Supply Co., Inc.
1955: 15 Apr., 14A
Microchemical Specialties Co.
1955: 12 Aug., 270; 21 Oct., 722
Perkin-Elmer Corp.
1954: 29 Oct., 2C
Photovolt Corp.
1954: 26 Nov., 3A; 17 Dec., 2A; 24 Dec., 5A
1955: 7 Jan., 4A; 21 Jan., 6A; 4 Feb., 5A; 18 Feb., 8A; 4 Mar., 6A; 18 Mar., 8A; 1 Apr., 3C; 15 Apr., 8A; 29 Apr., 3A; 6 May, 11A; 20 May, 2A; 3 June, 5A; 24 June, 2A; 8 July, 89; 29 July, 211; 12 Aug., 299; 9 Sept., 486; 23 Sept., 574; 7 Oct., 662; 14 Oct., 670
Research Equipment Corp.
1954: 3 Dec., 14A; 17 Dec., 5A
1955: 14 Jan., 4A; 18 Feb., 8A; 11 Mar., 14A; 8 Apr., 4A; 30 Sept., 580
Specialized Instruments Corp.
1954: 17 Dec., 3A
1955: 18 Feb., 7A; 15 Apr., 2C
Standard Scientific Supply Corp.
1955: 24 June, 3C

EVAPORATORS

Aloe, A. S., Co., Aloe Scientific Div.
1955: 15 Apr., 3A; 3 June, 1A; 5 Aug., 218; 21 Oct., 779

FERMENTORS

New Brunswick Scientific Co.
1955: 22 Apr., 11A; 15 July, 134; 26 Aug., 387; 21 Oct., 798

FILM

Eastman Kodak Co.
1954: 12 Nov., 9A; 10 Dec., 9A
1955: 11 Feb., 9A; 8 Apr., 9A; 20 May, 9A; 10 June, 11A; 7 Oct., 653

FILTERS

Millipore Filter Corp.
1955: 21 Oct., 718

FILTERS, COLOR

Eastman Kodak Co.
1955: 9 Sept., 477

FILTERS, INTERFERENCE

Baird Associates, Inc.
1955: 15 Apr., 4A
Fish-Schurman Corp.
1955: 18 Feb., 6A; 21 Oct., 801
Photovolt Corp.
1954: 29 Oct., 3A, and in every issue of *Science* through 31 Dec., 4A
1955: 7 Jan., 4A, and in every issue of *Science* through 24 June, 2A; 8 July, 89; 26 Aug., 390; 9 Sept., 486; 23 Sept., 574; 7 Oct., 662

FLUOROMETER

Biddle, James G., Co.
1955: 27 May, 13A; 29 July, 180
Farrand Optical Co., Inc.
1955: 18 Mar., 6A; 17 June, 3A

FRACTION COLLECTORS

GME (Gilson Medical Electronics)
1954: 3 Dec., 18A; 17 Dec., 12A
1955: 15 Apr., 11A; 13 May, 3C
Packard Instrument Co.
1955: 1 Apr., 5A; 6 May, 2A; 3 June, 11A; 8 July, 52; 21 Oct., 786
Research Equipment Corp.
1954: 29 Oct., 3C; 5 Nov., 2A; 12 Nov., 6A; 19 Nov., 2A; 26 Nov., 4A; 10 Dec., 4A; 31 Dec., 3A
1955: 28 Jan., 3A; 25 Feb., 3A; 25 Mar., 2A; 22 Apr., 2A; 1 July, 6; 2 Sept., 435
Technicon Chromatography Corp.
1954: 31 Dec., 2C
1955: 25 Mar., 2C; 12 Aug., 266

FRACTOMETER

Perkin-Elmer Corp.
1955: 7 Oct., 619

FREEZING EQUIPMENT

American Hospital Supply Corp., Science Products Div.
1955: 11 Feb., 1A; 19 Aug., 310
Machlett, E., & Son
1954: 3 Dec., 27A
1955: 30 Sept., 608
Niagara Blower Co.
1955: 21 Oct., 723
Phipps & Bird, Inc.
1955: 9 Sept., 452; 23 Sept., 575; 7 Oct., 622

FURNACES

Brinkmann, C. A., & Co.
1955: 18 Feb., 10A
Standard Scientific Supply Corp.
1955: 16 Sept., 498

FURNITURE, LABORATORY

Aloe, A. S., Co., Aloe Scientific Div.
1954: 3 Dec., 15A
Labline, Inc.
1955: 23 Sept., 539; 21 Oct., 795
Palo Laboratory Supplies, Inc.
1955: 11 Mar., 3A; 21 Oct., 776
Precision Scientific Co.
1955: 10 June, 4A, 5A
Technicon Co.
1954: 5 Nov., 2C; 3 Dec., 2C
1955: 11 Feb., 2C; 11 Mar., 2C; 8 Apr., 2C; 20 May, 2C; 1 July, 2; 26 Aug., 354; 23 Sept., 538; 21 Oct., 714

GLASSWARE AND ACCESSORIES

Central Scientific Co.
1955: 27 May, 5A; 15 July, 99
Corning Glass Works
1954: 19 Nov., 1A; 17 Dec., 1A
1955: 7 Jan., 8A; 4 Mar., 3C; 6 May, 3C; 10 June, 13A; 2 Sept., 439; 21 Oct., 715
Fish-Schurman Corp.
1955: 16 Sept., 526

Graf-Apsco Co.
1954: 3 Dec., 8A
1955: 14 Jan., 6A; 4 Feb., 2A; 18 Feb., 20A; 13 May, 4A; 3 June, 4A; 2 Sept., 398; 16 Sept., 526
United Scientific Co.
1955: 29 Apr., 2C

MICROSCOPE ACCESSORIES

American Optical Instrument Div.
1954: 12 Nov., 4C
1955: 18 Feb., 4C; 13 May, 4C
Bausch & Lomb Optical Co.
1955: 1 Apr., 8A; 15 Apr., 18A; 29 Apr., 6A; 22 July, 144
Custom Scientific Instruments, Inc.
1954: 19 Nov., 9A
1955: 4 Feb., 6A
Fish-Schurman Corp.
1955: 21 Jan., 12A; 24 June, 4A
Hacker, William J., & Co., Inc.
1955: 18 Mar., 8A; 1 Apr., 9A
Keyes, Frederick G., Inc.
1954: 26 Nov., 3A
1955: 28 Jan., 2A
Leitz, E., Inc.
1955: 1 July, 5; 26 Aug., 355; 2 Sept., 397; 21 Oct., 717
Rosenthal, Paul
1955: 30 Sept., 608; 21 Oct., 774
Silge & Kuhne
1955: 22 Apr., 6A; 9 Sept., 447

MICROTOMES AND ACCESSORIES

Aloe, A. S., Co., Scientific Div.
1954: 5 Nov., 3A
1955: 18 Feb., 5A
American Optical Instrument Div.
1955: 10 June, 4C
Hacker, Wm. J., & Co., Inc.
1954: 24 Dec., 6A
1955: 7 Jan., 2A; 4 Feb., 4A
Leitz, E., Inc.
1955: 14 Oct., 671
Machlett, E., & Son
1955: 14 Jan., 3A
Sorvall, Ivan, Inc.
1955: 14 Jan., 12A; 4 Mar., 11A; 15 Apr., 9A; 3 June, 4A; 1 July, 43; 21 Oct., 721
Technical Instrument Co.
1954: 29 Oct., 4A
Technicon Co.
1954: 19 Nov., 2C
1955: 17 June, 2C

MOLECULAR MODELS

LaPine, Arthur S., and Co.
1955: 16 Sept., 490

MONOCHROMATORS

Biddle, James G., Co.
1955: 27 May, 13A; 29 July, 180
Farrand Optical Co., Inc.
1954: 26 Nov., 3C
1955: 15 Apr., 4A; 13 May, 12A
Jarrell-Ash Co.
1955: 15 Apr., 19A; 9 Sept., 449
Perkin-Elmer Corp.
1954: 3 Dec., 3C
1955: 11 Feb., 3A

MOTORS

Daigger, A., & Co.
1955: 23 Sept., 576

NEEDLE PULLER

Brinkmann Instruments, Inc.
1955: 25 Feb., 7A

OPTICAL EQUIPMENT

Baird Associates, Inc.
1954: 10 Dec., 6A
1955: 15 Apr., 4A
Biddle, James G., Co.
1954: 19 Nov., 11A
1955: 25 Mar., 6A; 26 Aug., 391
Custom Scientific Instruments, Inc.
1955: 7 Jan., 6A
Edmund Scientific Corp.
1954: 5 Nov., 5A; 3 Dec., 3A
1955: 7 Jan., 3A; 4 Feb., 2C; 4 Mar., 3A; 8 Apr., 5A; 6 May, 3A; 3 June, 3A; 8 July, 53; 5 Aug., 255; 9 Sept., 446; 7 Oct., 659
Ednalite Optical Co.
1955: 18 Feb., 13A
Farrand Optical Co., Inc.
1955: 14 Jan., 15A
Fish-Schurman Corp.
1954: 3 Dec., 16A; 21 Oct., 801
Hacker, Wm. J., & Co., Inc.
1954: 17 Dec., 5A; 31 Dec, 1A
1955: 14 Jan., 12A
Perkin-Elmer Corp.
1954: 3 Dec., 3C
1955: 11 Feb., 3A
Umeco Optical Co.
1955: 14 Jan., 3A

OVENS

Daigger, A., & Co.
1955: 21 Oct., 807
Labline, Inc.
1955: 23 Sept., 539; 21 Oct., 795
Precision Scientific Co.
1954: 29 Oct., 7A; 10 Dec., 3A
1955: 21 Jan., 3A; 11 Mar., 4A; 10 June, 4A, 5A; 9 Sept., 444
Schaar and Co.
1955: 3 June, 3C

PERISCOPES

General Electric Co.
1954: 5 Nov., 7A

PETROLEUM–TESTING EQUIPMENT

Precision Scientific Co.
1955: 11 Mar., 4A; 9 Sept., 444

Labline, Inc.
1955: 23 Sept., 539; 21 Oct., 795

pH INDICATORS

Applied Physics Corp.
1955: 21 Oct., 781
LaMotte Chemical Products Co.
1955: 11 Feb., 6A; 9 Sept., 483
Cambridge Instrument Co., Inc.
1955: 18 Feb., 4A; 25 Mar., 6A
Photovolt Corp.
1955: 11 Mar., 6A; 13 May, 8A; 1 July, 4; 15 July, 102; 5 Aug., 257; 19 Aug., 347; 2 Sept., 396; 16 Sept., 496; 30 Sept., 580; 21 Oct., 784

PHOSPHORS

General Electric Co.
1955: 7 Jan., 5A

PHOTOCOPIERS

Eastman Kodak Co.
1955: 12 Aug., 295
Ludwig, F. W., Inc.
1955: 18 Feb., 4A; 17 June, 6A

PHOTOGRAPHIC EQUIPMENT

Eastman Kodak Co.
1955: 7 Jan., 11A; 11 Mar., 9A

PHOTOMETERS, EXPOSURE

Brinkmann Instruments, Inc.
1954: 3 Dec., 16A
1955: 3 June, 6A
Photovolt Corp.
1954: 19 Nov., 5A; 31 Dec., 4A
1955: 28 Jan., 3A; 25 Feb., 4A; 25 Mar., 4A; 22 Apr., 2A; 10 June, 2A
Rosenthal, Paul
1955: 30 Sept., 614; 21 Oct., 720

PHOTOMETERS, FLAME

Biddle, James G., Co.
1955: 27 May, 13A; 29 July, 180
Machlett, E., & Son
1955: 25 Mar., 5A
Standard Scientific Supply Corp.
1954: 19 Nov., 8A
1955: 18 Feb., 3C

PHOTOMETERS, MICRO

Jarrell-Ash Co.
1955: 11 Mar., 1A; 13 May, 15A; 10 June, 2C; 14 Oct., 669

PHOTOMETERS, MULTIPLIER

Missouri Research Laboratories
1955: 28 Jan., 1A
Photovolt Corp.
1954: 5 Nov., 4A; 10 Dec., 5A
1955: 14 Jan., 7A; 11 Feb., 6A; 8 Apr., 6A; 27 May, 2A; 17 June, 3A; 22 July, 168; 26 Aug., 391; 14 Oct., 670

PHOTOMETERS, X-RAY

General Electric Co.
1955: 7 Oct., 663

PHOTROMETER

Leitz, E., Inc.
1955: 16 Sept., 493

PIPETTE FILLERS

Instrumentation Assoc.
1955: 21 Oct., 774
National Instrument Co.
1955: 21 Oct., 798

PIPETTE WASHER

Technicon Co.
1955: 14 Jan., 2C

PLASTIC SEALER

Scientific Specialties Corp.
1955: 28 Jan., 4A

POLARIMETERS

Fish-Schurman Corp.
1954: 3 Dec., 16A
Jarrell-Ash Co.
1955: 15 Apr., 19A; 9 Sept., 449
Rudolph, O. C., & Sons
1955: 18 Feb., 18A; 15 Apr., 10A; 21 Oct., 801
Zeiss, Carl, Inc.
1955: 13 May, 7A

POLISHER, METALLURGICAL

Precision Scientific Co.
1955: 11 Mar., 4A; 9 Sept., 444

POWER SUPPLY

Farrand Optical Co., Inc.
1954: 3 Dec., 10A

PRESS, LABORATORY

Carver, Fred S., Inc.
1954: 3 Dec., 2A
1955: 18 Feb., 23A

PROJECTORS

Bausch & Lomb Optical Co.
1954: 26 Nov., 6A; 24 Dec., 4A
1955: 21 Jan., 8A; 5 Aug., 224; 19 Aug., 312; 2 Sept., 400
Eastman Kodak Co.
1954: 10 Dec., 9A
Ednalite Optical Co.
1955: 18 Feb., 13A
Leitz, E., Inc.
1955: 22 July, 141; 5 Aug., 221; 12 Aug., 267; 7 Oct., 621
Scopicon Co.
1955: 28 Jan., 2C; 15 July, 98

PUMPS

Wakefield Industries, Inc.
1955: 18 Feb., 2A

PUMPS, BOTTLE

Standard Scientific Supply Corp.
1955: 16 Sept., 498

PUMPS, RESPIRATION

Harvard Apparatus Co., Inc.
1954: 24 Dec., 6A
Stoelting, C. H., Co.
1955: 26 Aug., 391

PUMPS, VACUUM

Central Scientific Co.
1955: 24 June, 5A
General Electric Co.
1954: 5 Nov., 7A
Welch, W. M., Manufacturing Co.
1955: 1 July, 8; 23 Sept., 544

RADIATION COUNTERS

Beckman Instruments, Inc., Berkeley Div.
1955: 25 Mar., 3A; 5 Aug., 222; 2 Sept., 434
Cambridge Instrument Co., Inc.
1954: 3 Dec., 6A
1955: 18 Feb., 4A; 16 Sept., 534
Ken Research, Inc.
1955: 17 June, 5A
NRD Instrument Co.
1954: 12 Nov., 3A
1955: 7 Jan., 12A; 8 Apr., 2A; 3 June, 5A; 9 Sept., 448
Nuclear-Chicago
1955: 7 Jan., 15A; 27 May, 9A; 22 July, 169; 9 Sept., 444
Nuclear Measurements Corp.
1954: 19 Nov., 10A; 3 Dec., 14A
1955: 14 Jan., 7A; 11 Feb., 2A
Packard Instrument Co.
1955: 15 Apr., 13A; 27 May, 6A; 22 July, 138, 21 Oct., 786
Perkin-Elmer Corp.
1954: 3 Dec., 3C
1955: 11 Feb., 3A
Tracerlab, Inc.
1954: 19 Nov., 3C; 17 Dec., 3C
1955: 14 Jan., 3C; 11 Feb., 8A; 11 Mar., 3C; 15 Apr., 3C; 13 May, 11A; 17 June, 1A; 15 July, 135

RADIATION RESEARCH EQUIPMENT

Applied Physics Corp
1955: 21 Oct., 781
Tracerlab, Inc.
1955: 16 Sept., 494; 14 Oct., 666

RECORDING EQUIPMENT, BIOPHYSICAL

American Electronic Laboratories, Inc.
1955: 21 Oct., 793
Electro-Medical Laboratory, Inc.
1954: 29 Oct., 2A; 26 Nov., 4A; 24 Dec., 2A
1955: 21 Jan., 10A; 1 Apr., 11A; 29 Apr., 4A; 27 May, 13A; 24 June, 2A; 22 July, 174; 19 Aug., 345; 16 Sept., 534; 14 Oct., 704
GME (Gilson-Medical Electronics)
1954: 17 Dec., 12A
Harvard Apparatus Co., Inc.
1955: 3 June, 6A
Lab-Tronics, Inc.
1955: 4 Mar., 2C; 21 Oct., 789
Packard Instrument Co.
1955: 21 Oct., 786
Phipps & Bird, Inc.
1954: 3 Dec., 11A; 31 Dec., 6A
1955: 28 Jan., 6A; 25 Mar., 4C; 22 Apr., 4C; 13 May, 6A; 27 May, 11A; 3 June, 2A
Photovolt Corp.
1954: 3 Dec., 12A
Sanborn Co.
1954: 26 Nov., 2C; 3 Dec., 7A
Stoelting, C. H., Co.
1955: 29 July, 180

RECORDING EQUIPMENT, PHARMACOLOGICAL

Brinkmann, C. A., & Co.
1954: 31 Dec., 1A

REFRACTOMETERS

American Optical Instrument Div.
1955: 15 Apr., 4C; 8 July, 96
Jarrell-Ash Co.
1955: 15 Apr., 19A; 9 Sept., 449

RESPIRATORY METER

Phipps & Bird, Inc.
1955: 27 May, 11A

RHEOSTATS

Biddle, James G., Co.
1955: 14 Jan., 12A; 30 Sept., 609

SCALES, MOUSE

Taconic Farms
1955: 21 Oct., 774

SCALER, AUTOMATIC

NRD Instrument Co.
1954: 12 Nov., 3A

SCIENTIFIC ILLUSTRATIONS

John Gilmore
1955: 23 Sept., 540

SHAKERS

New Brunswick Scientific Co.
1955: 18 Mar., 19A; 8 Apr., 11A; 6 May, 6A; 20 May, 6A; 17 June, 2A; 1 July, 6; 29 July, 180; 12 Aug., 297; 9 Sept., 480; 23 Sept., 574; 7 Oct., 620

SHUTTER, CAMERA

Eastman Kodak Co.
1955: 9 Sept., 477

SILICONES, RADIOACTIVE

General Electric Co.
1954: 5 Nov., 7A

SKELETON, MODEL

Welch, W. M., Manufacturing Co.
1955: 4 Mar., 8A; 29 July, 182

SPECTROGRAPHS

Jarrell-Ash Co.
1955: 11 Mar., 1A; 13 May, 15A; 10 June, 2C; 14 Oct., 669

SPECTROMETERS AND ACCESSORIES

American Optical Instrument Div.
1955: 7 Jan., 4C
Baird Associates, Inc.
1954: 12 Nov., 6A
Biddle, James G., Co.
1955: 29 July, 180
Farrand Optical Co., Inc.
1955: 13 May, 12A
Jarrell-Ash Co.
1955: 13 May, 15A; 10 June, 2C; 14 Oct., 669
Packard Instrument Co.
1955: 21 Oct., 786
Perkin-Elmer Corp.
1955: 1 July, 3

SPECTROPHOTOMETERS AND ACCESSORIES

American Optical Instrument Div.
1955: 1 Apr., 4C; 22 July, 176; 2 Sept., 440
Applied Physics Corp.
1955: 21 Oct., 781
Biddle, James G., Co.
1955: 27 May, 13A; 29 July, 180
Eastman Kodak Co.
1955: 11 Mar., 9A
Jarrell-Ash Co.
1955: 15 Apr., 19A; 9 Sept., 449
Machlett, E., & Son
1955: 22 July, 140
Perkin-Elmer Corp.
1955: 7 Jan., 3C; 18 Mar., 3A; 27 May, 2C
Thomas, Arthur H., Co.
1954: 5 Nov., 4C; 3 Dec., 4C

STAINS, BIOLOGICAL

Matheson, Coleman & Bell
1954: 3 Dec., 2A
1955: 24 June, 2C
Ortho Pharmaceutical Corp.
1954: 12 Nov., 3C

STERILIZERS

Precision Scientific Co.
1955: 10 June, 4A, 5A
Wilmot Castle Co.
1954: 17 Dec., 6A
1955: 14 Jan., 2A; 9 Sept., 480; 14 Oct., 705

STILLS

Machlett, E., & Son
1955: 6 May, 5A; 13 May, 13A

STILLS, WATER

Precision Scientific Co.
1955: 21 Jan., 2A; 9 Sept., 445; 21 Oct., 725

STIMULATORS

American Electronic Laboratories, Inc.
1955: 7 Jan., 2A; 9 Sept., 448; 21 Oct., 793
Harvard Apparatus Co., Inc.
1954: 12 Nov., 2A; 3 Dec., 6A
Lab-Tronics, Inc.
1955: 25 Mar., 1A
Thomas, Arthur H., Co.
1954: 31 Dec., 4C

STIRRERS

Palo Laboratory Supplies, Inc.
1954: 3 Dec., 10A
1955: 28 Jan., 3C
Precision Scientific Co.
1955: 20 May, 4A; 21 Oct., 724

STOP WATCHES

Daigger, A., & Co.
1955: 23 Sept., 576
Precision Scientific Co.
1955: 11 Mar., 4A; 9 Sept., 444

SWIMMING POOL, CHLORINE AND ALKALINITY TEST

LaMotte Chemical Products Co.
1955: 11 Mar., 2A; 8 Apr., 13A; 13 May, 17A; 10 June, 4A

SYNCHROTRONS

General Electric Co.
1955: 8 Apr., 3A

TEST CABINET, AIR-CONDITIONED

Niagara Blower Co.
1955: 22 Apr., 13A; 20 May, 10A; 17 June, 2A; 15 July, 102; 12 Aug., 270; 9 Sept., 486; 21 Oct., 723

TEST, ENDOCRINE

Endocrine Laboratories of Madison, Inc.
1955: 14 Jan., 4A; 28 Jan., 2A; 18 Feb., 18A; 18 Mar., 12A; 15 Apr., 12A; 13 May, 12A; 10 June, 4A; 15 July, 134; 12 Aug., 297; 16 Sept., 534; 14 Oct., 668

TESTERS, FLASH POINT

Precision Scientific Co.
1955: 21 Jan., 2A

ADVERTISERS APPEARING IN "THE MARKET PLACE" SECTION OF *SCIENCE*, 29 OCT 1954 THROUGH 21 OCT. 1955.

Abrahams Magazine Service
56 E. 13 St., New York 3, N.Y.

Albino Farms
Box 331, Red Bank, N.J.

American-Lincoln Incubator Co.
New Brunswick, N.J.

Applied Science Laboratories, Inc.
140 North Barnard St., State College, Pa.

Archbald Associates
Box 152, East Aurora, N.Y.

Arctic Institute of North America
1530 P St., NW, Washington 5, D.C.

Ashley-Ratcliff Corp.
24 E. 21 St., New York 10, N.Y.

Beckman Instruments, Inc., Berkeley Div.
2200 Wright Ave., Richmond 3, Calif.

Beta Laboratories, Inc.
205 N. 3 St., Philadelphia 6, Pa.

Bios Laboratories
17 W. 60 St., New York 23, N.Y.

Biotronics Laboratories
Silver St., Coventry, Conn.

Budd Mt. Rodent Farm
R.R.1, Chester, N.J.

Canner, J. S., Inc.
Dept. A3S, Boston 19, Mass.

Cargille, R. P., Laboratories
117 Liberty St., New York, N.Y.

Charles River Breeding Labs.
Wilmington, Mass.

Current Articles Unlimited, Spartan Co.,
18 E. 17 St., New York 3, N.Y.

Dajac Laboratories (Monomer Polymer)
Leominster, Mass.

Dog Farm
R.R.1, Ithaca, N.Y.

Eberbach & Son
Ann Arbor, Mich.

Englewood Publishing Co.
43 Belmont St., Englewood, N.J.

Exposition Press
386 Fourth Ave., New York 16, N.Y.

Falcon's Wing Press
Indian Hills, Colo.

Flanders Research Farms
Box 22A, Flanders, N.J.

Food Research Laboratories, Inc.
48–14 33 St., Long Island City 1, N.Y.

Frontier Instruments
Dept. S., Box 276, Annandale, Va.

General Biochemicals, Inc.
72 Laboratory Park, Chagrin Falls, Ohio

GME (Gilson-Medical Electronics)
714 Market Place, Madison 3, Wis.

Greenwich Book Publishers, Inc.
489 Fifth Ave., New York 17, N.Y.

Hacker, Wm. J. & Co., Inc.
82 Beaver St., New York 5, N.Y.

H. M. Chemical Co.
1651 18 St., Santa Monica, Calif.

Holtzman Rat Co.
R.4, Box 205, Madison 4, Wis.

Hormone Assay Laboratories, Inc.
8159 S. Spaulding Ave., Chicago 29, Ill.

Isotopes Specialties Co., Inc.
703 S. Main St., Burbank, Calif.

Johnson, Walter J.
125 E. 23 St., New York 10, N.Y.

LaWall & Harrisson
1921 Walnut St., Philadelphia 3, Pa.

Lovins Engineering Co.
Box 429, Silver Spring, Md.

Lurie, F. G.
834 E. 90 St., Chicago 19, Ill.

Machlett, E., & Son
220 E. 23 St., New York 10, N.Y.

Mann Research Laboratories
136 Liberty St., New York 6, N.Y.

Manor Farms
Staatsburg, N.Y.

Medical Center Laboratory
519 E. Club Blvd., Durham, N.C.

Medical-Electronics Development Co.
Box 443, Great Neck, L.I., N.Y.

National Press
435 Alma St., Palo Alto, Calif.

Northeast Biological Laboratory
Brookfield, N.H.

Northwest Rodent Co.
R.2, Pullman, Wash.

Nutritional Biochemicals Corp.
Cleveland 28, Ohio

Orlando Research, Inc.
Box 6491, Orlando, Fla.

Pacific Animal Farms
2457 Fletcher Dr., Los Angeles 39, Calif.

Palo Laboratory Supplies, Inc.
81 Reade St., New York 7, N.Y.

Pan-L-View
708 Church St., Evanston, Ill.

Precision Laboratories
Rm. 310, 4554 N. Broadway, Chicago 40, Ill.

Principia Press, Inc.
Bloomington, Ind.

Research Specialties Co.
1148 Walnut St., Berkeley 7, Calif.

Rolfsmeyer, Dan, Co.
R. 3, Syene Rd. Madison, Wis.

Ross Allen Reptile Inst.
Silver Springs, Fla.

Rudolph, O. C., & Sons
Box 446, Caldwell, N.J.

St. John X-Ray Laboratory
Califon, N.J.

Science House, Inc.
Box 7913, Pittsburgh 16, Pa.

Shankman Laboratories
2023 S. Santa Fe Ave., Los Angeles 21, Calif.

Sobotka, Eric, Co.
102 W. 42 St., New York 36, N.Y.

South Shore Analytical and Research Laboratory, Inc.
148 Islip Ave., Islip, N.Y.

Sprague-Dawley, Inc.
Box 2071, Madison, Wis.

Starkman Biological Laboratory
461 Bloor St., W., Toronto, Canada

Stokeley-Peterson, Inc.
Box 1254, Madison 1, Wis.

Taconic Farms
Germantown, N.Y.

Technican Instrument Co.
122 Golden Gate Ave., San Francisco 2, Calif.

Technicon Chemical Co., Inc.
Chauncey, N.Y.

Tropical Biologicals
Box 2227, San Juan, Puerto Rico

Truesdail Laboratories, Inc.
4101 N. Figueroa St., Los Angeles 65, Calif.

Union Internationale des Sciences Biologiques
1 rue Victor Cousin, Paris (5), France

Vantage Press, Inc.
120 W. 31 St., New York 1, N.Y.

Wallace and Tiernan, Inc.
Box 178, Newark 1, N.J.

Wisconsin Alumni Research Foundation
Box 2059, Madison 1, Wis.

Worldpost
Tangier, Morocco

PERSONNEL PLACEMENT

YOUR ad here reaches over 32,000 foremost scientists in the leading educational institutions, industrial laboratories, and research foundations in the U. S. and 76 foreign countries —at a very low cost.

CLASSIFIED: 18¢ per word, minimum charge $3.60. Use of Box Number counts as 10 additional words.

DISPLAY: Rates listed below — no charge for Box Number. Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	**$22.00 per inch**
13 times in 1 year	**21.00 per inch**
26 times in 1 year	**20.00 per inch**
52 times in 1 year	**19.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

POSITIONS WANTED

Bacteriologist, Ph.D., 9 years research and teaching; highly recommended for any position in field of bacteriology including diagnostic bacteriologic work, bacteriological research and teaching. Medical Bureau (Burneice Larson, Director), Palmolive Building, Chicago. X

Medical Writer, woman; medical science background; experienced pharmaceutical company and advertising agency; New York City area. Box 259, SCIENCE. X

Successful Pharmacologist, Ph.D., Industrial research directorship; new product experience. Interested in pharmaceutical, food industry, and research institution. Box 260, SCIENCE. X

POSITIONS OPEN

(a) **Bacteriologist,** Ph.D., bacteriology or microbiology; clinical and teaching duties, large general hospital; to $6500; West. (b) **Microbiologist,** Ph.D., prefer experience with infection in animals and immunology background; principal duties research; some graduate level teaching; East. (c) **Junior Pharmacologist,** B.S. or M.S., physiology or pharmacology; screening and special procedures on new drugs; pharmaceutical house; to $4500; East. (d) **Research Assistant,** Virology; M.S. preferred; perform animal, egg inoculations, serological determinations, also handle infectious human, animal pathogens; potential virology section head; East. (e) **Research Associate,** Ph.D., physiologist, pharmacologist, biochemist; duties include administration, consultation, technical writing, editing; no laboratory research involved; to $5000 or better; Southeast. (f) **Manufacturing Biochemist,** Ph.D., supervise manufacture of biological products; to $8500; East. Woodward Medical Bureau, 185 N. Wabash, Chicago, Ill. X

Research Chemist, Ph.D.; for work in radioisotopes laboratory applying tracer techniques to research problems in biochemistry, pharmacology, analytical chemistry, etc. Previous tracer experience desirable but not essential. Send resumé to Business Manager, The Squibb Institute for Medical Research, New Brunswick, N. J. X

Research Associate for research position in industrial pharmacy (eastern seaboard); minimum requirement Ph.D. in pharmacy or in related field with industrial experience. Salary open. Box 255, SCIENCE. 10/14, 21, 28

POSITIONS OPEN

Bacteriologist, Ph.D.; must have at least 10 years industrial experience. Duties will be divided between manufacturing and product development. Must have had experience with bacterial vaccines and related products. Write: Ralph L. Sherman, Sherman Laboratories, 5031 Grandy, Detroit 11, Mich. X

(a) **Physician,** well trained in hematology or nutrition; also one qualified in a biological science to serve as assistant director clinical research, duties principally administrative; pharmaceutical company; (b) **Statistician** to serve as assistant or associate professor, university school of medicine. (c) **Copy Writer;** professional publications; national coverage. (d) **Physicist** or **Biophysicist,** Ph.D., with experimental experience, research post; $6300–7500; South. (e) **Biochemist** to head department, 22-man group established 1901; college town; Midwest. S10-3 Medical Bureau (Burneice Larson, Director), Palmolive Building, Chicago. X

Technician for production of microscope slides. Training in zoology and zoological microtechnique essential. Must have primary interest in technique preferably in the invertebrate field. Knowledge of vertebrate embryological preparation also desirable. Wards Natural Science Establishment, Inc., 3000 East Ridge Rd., Rochester 9, N. Y. X

Research Assistant for research position in industrial pharmacy (eastern seaboard); minimum requirement M.S. in pharmacy or in related field with industrial experience. Salary open. Box 256, SCIENCE. 10/14, 21, 28

The MARKET PLACE

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Rates listed below—no charge for Box Number. Monthly invoices will be sent on a charge account basis —provided that satisfactory credit is established.

Single insertion	**$22.00 per inch**
13 times in 1 year	**21.00 per inch**
26 times in 1 year	**20.00 per inch**
52 times in 1 year	**19.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

WANTED TO PURCHASE . . .

SCIENTIFIC PERIODICALS and BOOKS } Sets and runs, foreign and domestic. Entire libraries and smaller collections wanted

WALTER J. JOHNSON • 125 East 23rd St., New York 10, N. Y.

Scientific Periodicals. Bought at Top Prices. Ashley-Ratcliff Corp., 27 East 21 Street, New York 10, N. Y.

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, J. S. CANNER, INC. Boston 19, Massachusetts

PROFESSIONAL SERVICES

FOOD RESEARCH LABORATORIES, INC.
Founded 1922
Philip B. Hawk, Ph.D., President
Bernard L. Oser, Ph.D., Director
Research • Analyses • Consultation
Biological, Nutritional, Toxicological Studies for the Food, Drug and Allied Industries
48-14 33rd Street, Long Island City 1, N.Y.

• RESEARCH
• CONSULTATION
• ANALYSES

BOOK MANUSCRIPTS INVITED

Write for Free Booklet SC telling how we can publish your book. All subjects considered. New authors welcome.

VANTAGE PRESS, Inc. • 120 W. 31 St., New York 1
In Calif.: 6253 Hollywood Blvd., Hollywood 28

WISCONSIN ALUMNI RESEARCH FOUNDATION

LABORATORY SERVICES

Project research and consultation in Biochemistry, Chemistry, Bacteriology and Entomology

Amino acid assays and biological protein evaluations • Vitamin and antibiotic assays • Chick feeding tests • Pharmacology including warm-blooded toxicity studies • Phenol coefficient determinations

Write for price schedule

WISCONSIN ALUMNI RESEARCH FOUNDATION
P. O. BOX 2059-V • MADISON 1, WISCONSIN

FILM MONITORING SERVICE
ST. JOHN X-RAY LABORATORY
CALIFON, NEW JERSEY
Established 1925

The MARKET PLACE

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

PROFESSIONAL SERVICES

CONSULTATION
RESEARCH

MICROBIOLOGY
PHARMACOLOGY
BIOCHEMISTRY
TOXICOLOGY
ANIMAL HISTOPATHOLOGY

SOUTH SHORE
ANALYTICAL AND RESEARCH LABORATORY, Inc.
148 ISLIP AVE. ISLIP, N. Y.

TRUESDAIL LABORATORIES, INC.

Roger W. Truesdail, Ph.D., President
C. E. P. Jeffreys, Ph.D., Technical Director

CHEMISTS • BACTERIOLOGISTS • ENGINEERS
Write for Brochure • 4101 North Figueroa Street
Los Angeles 65, California • CApitol 4148

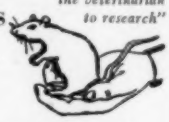
Applied Research
Consultation
Analyses
Testing
Charter Member ACIL

SUPPLIES AND EQUIPMENT

ALBINO RATS*

"From the hand of the veterinarian to research"

HYPOPHYSECTOMIZED RATS
**Descendants of the Sprague-Dawley and Wistar Strains*



HENRY L. FOSTER, D.V.M.
President and Director
THE CHARLES RIVER BREEDING LABS.
Wilmington, Mass.

All AMINO ACIDS— natural, synthetic, unnatural, Rare Sugars, Biochemical Products, Reagents, New Pharmaceuticals in stock. Write or phone PLaza 7-8171 for complete price list.
BIOS LABORATORIES, INC. 17 West 60th Street, New York 23, N. Y.

• *Hamsters* • *Guinea Pigs* • *Rabbits* •

Mice • *Rats* • *Cats* • *Dogs*

MANOR FARMS
Staatsburg, New York
Tel. Staatsburg TU 9-3278
RESEARCH
Supplying every Research Need Since 1943

GME
714 MARKET PLACE
MADISON 3, WIS.

FRACTIONATORS • TRANSFERATORS
CARDIOVASCULAR RECORDERS
ELECTROENCEPHALOGRAPHS
WARBURG APPARATUS
WATER BATHS

for

- **MICROSCOPES**
- **MICROTOMES**
- **ILLUMINATORS**

Specializing in equipment made in all Zeiss and Leitz factories

Write to
ERIC SOBOTKA CO. • 102 West 42d Street New York 36, N. Y.

SUPPLIES AND EQUIPMENT

Labtician Imported Features . . . .

- Lang-Levy Pipettes
- All Nylon Unbreakable Syringes
- An efficient swedish Paper-Electrophoresis instrument
- Hexagon based graduated cylinders with Schellbach, blue, gold or red background

For price list and Literature write
LABTICIAN PRODUCTS COMPANY
190-04 99th Avenue, Hollis 23, N. Y.

RATS

Long-Evans (PAF)
Wistar (PAF)

Bred for Research Work by Research Workers
PACIFIC ANIMAL FARMS
2457 Fletcher Dr., Los Angeles 39, Calif.

• **HYPOPHYSECTOMIZED RATS**
Shipped to all points via Air Express
For further information write
HORMONE ASSAY LABORATORIES, Inc. • 8159 South Spaulding Ave. Chicago 29, Ill.

RESEARCH BIOCHEMICALS
OVER 1500
NUTRITIONAL BIOCHEMICALS Corp.
Cleveland 28, Ohio
Write for your copy—free catalogue—Dept. 102

BEAGLES

Healthy — AKC Registered — Immunized
$25 to $50 each; F.O.B. Ithaca
ITHACA DOG FARM — RR1 — Ithaca, N. Y.

SWISS MICE
TACONIC FARMS
GERMANTOWN NEW YORK
GERMANTOWN 3535

Orotic Acid-2 C^{14}
and other tagged compounds
OF HIGH RADIOPURITY
ISOTOPES SPECIALTIES COMPANY INC. 703A South Main St. Burbank, Calif.

PARLIAMENTARY SLIDE RULE—settles questions of parliamentary procedure for committees and meetings operating under standard rules of order. This vinyl plastic slide rule provides immediate answers to eight basic questions on the 36 most common motions. Based on **Robert's Rules of Order Revised.** $3.00 postpaid. **PAN-L-VIEW, 708 Church Street, Evanston, Illinois.**

APPLICATION FOR HOTEL RESERVATIONS
122nd AAAS MEETING
Atlanta, Ga., December 26-31, 1955

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel room reservation in Atlanta. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Atlanta and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less. **As in any city, single-bedded rooms may become scarce; double rooms for single occupancy cost more; if possible, share a twin-bedded room with a colleague—and also save money.** Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

HOTELS AND RATES PER DAY

★ **Hotels starred have sessions in their public rooms.** Most hotels will place comfortable rollaway beds in rooms or suites at 2.50 or 3.00 per night. For a list of headquarters of each participating society and section—and for information on **dormitory accommodations** at Atlanta University and Georgia Institute of Technology—please see *Science*, July 22, or *The Scientific Monthly*, August.

Hotel★	Single	Double Bed	Twin Bed	Suite
Georgia Tech Zone				
Atlanta Biltmore★	6.00–10.00	8.00–14.00	10.00–14.00	15.00–50.00
Cox-Carlton	4.00– 6.00	6.00– 8.00	6.00– 8.00	14.00–16.00
Georgian Terrace	5.00– 8.00	8.50–11.00	8.50–12.00	12.00–22.00
Peachtree Manor	5.00– 8.00	7.50– 9.50	8.50–12.00	15.00–28.00
Downtown Zone				
Atlantan	4.00– 5.50	6.00– 8.50	8.50–10.50	17.00
Dinkler Plaza★	6.00– 8.50	7.00–11.50	13.00–15.00	12.00–35.00
Georgia★	4.00– 7.00	6.00– 9.00	7.00–10.00	15.00–20.00
Hampton	2.50– 4.00	3.50– 5.00	5.00– 7.00	
Henry Grady★	5.50–12.00	9.00–12.00	9.50–12.00	16.00–25.00
Imperial	4.00– 5.50	6.00– 6.50	6.50– 7.00	
Jefferson	3.00– 3.50	4.00– 5.00	4.50– 5.00	
Peachtree on Peachtree	5.00– 7.00	7.50–10.50	8.50–10.50	10.00–18.00
Piedmont★	5.50– 8.00	7.50–10.00	10.00–14.00	20.00–25.00
As required by local laws, the following are available for Negro members and visitors:				
Royal Hotel 214 Auburn Ave., N.E.	4.00	5.00		
Savoy Hotel 239 Auburn Ave., N.E.	2.50	3.50– 4.50		
University Motel 55 Northside Drive, N.W.	5.00	8.00		

THIS IS YOUR HOTEL RESERVATION COUPON

AAAS Housing Bureau
Room 912, Rhodes-Haverty Bldg.
Atlanta 3, Ga.

Date of Application .....

Please reserve the following accommodations for the 122nd Meeting of the AAAS in Atlanta, Dec. 26–31, 1955:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Desired Rate ..... Maximum Rate .....
Double-Bedded Room ..... Desired Rate ..... Maximum Rate ..... Number in party .....
Twin-Bedded Room ..... Desired Rate ..... Maximum Rate .....
Suite ..... Desired Rate ..... Maximum Rate ..... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) (Please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

Mail this now to the Housing Bureau. **Rooms will be assigned and confirmed in order of receipt of reservation.**

Matchless Oven Performance at Low Cost

Engineered for long-life depedability in tough service, this new Robomatic offers you unprecedented economy in initial cost and operaiton! For innumerable heat control jobs—drying, baking, preheating, conditioning—where plus or minus 2 degree F control accuracy is adequate—or where larger ovens would impose wasteful power costs—there is no longer any need to invest in cumbersome, costly, current-wasting equipment.

No other oven near its price can equal the performance or value of this new Robomatic—for controlled temperature jobs in laboratory or production work.

work chamber exceeds a full cubic foot

Interior 13 x 13 x 13″

Actual work space exceeds a cubic foot—fully usable, clear and unobstructed. No comparable oven offers so much working capacity.

Control Accuracy ± 2° F

Plus or minus 2 deg. F. is actual control of work space, not inherent thermostat sensitivity, which much more precise. Settings reproducible by means of reference dial.

350° F Maximum Heat

Utilizes input wattage to the utmost, power consumption only 450 watts. No waste current, high efficiency. Higher ranges available special.

Fiber Glass Insulation

Insulating blanket 2″ thick in door, all sides and top. Non-hygroscopic, thermally efficient. Will not decompose. Silicone door gasket safeguards heat retention.

Double-Walled Construction

All steel, rigidly reinforced, smooth clean lines. Excellent craftsmanship in every detail, for years of service.

Black Heat Elements

Sheathed heaters of low wattage density. Safe, durable, efficient. Virtually no oxidation. No open wiring. No hot or cold spots. Heating by direct conduction to chamber walls, thence by radiation to load.

Air Control Shutter

Adjustable shutter at top governs air flow, allows vapor or gas exhaust from work chamber. Thermometer protrudes down thru shutter sleeve.

Two Adjustable Shelves

Perforated metal to allow air flow. Adjustable for height on brackets, in 1″ steps. Each shelf 13 x 13″ square, unobstructed.

Sensitive, hydraulic thermostat Underwriter's Approved!

ROBOMATIC MODEL 500 OVEN

Overall dimensions 22½ high, 17½ wide, 19″ deep. Net weight 48 lbs. Aluminized exterior. Complete with 2 shelves, mercury thermometer, thermometer holder, and pilot light. Power consumption 450 watts, on 110-125 volts AC 60 cycles. F.O.B. Chicago—

89.50

Other temperature controlled cabinets in a wide variety of sizes and heating ranges are available. Prices and specifications on request.

A. DAIGGER and COMPANY 157 W. KINZIE CHICAGO 10, ILL.

MORE AND MORE LABORATORIES

Rely on THOMAS

because . . .

You select from a 1736-page catalogue and supplement

An encyclopedic reference source with factual, detailed descriptions.

You deal with headquarters

All orders filled promptly from one vast warehouse.
Competent technological staff on call.

You draw on large stocks

Adequate stocks of 22,000 prepackaged items for immediate shipment.
Widest assortments of Corning, Kimble and Coors items available from any single source.

You save time and money

Expediting unnecessary — 83% of orders shipped day received or day following.
Accurate invoices and packing lists.
Adequate packing which keeps breakage to less than 1/20 of 1%.
Advance quotations unnecessary — one-price policy insures lowest prices to all buyers.

You are assured of satisfaction

Stocks carefully selected and continually inspected for dependable quality and satisfactory performance.
Prompt refund for any item found unacceptable for any reason.

SYMBOL OF QUALITY
A.H.T.CO.
SPECIFICATION
LABORATORY APPARATUS

ARTHUR H. THOMAS COMPANY

Laboratory Apparatus and Reagents

WEST WASHINGTON SQUARE PHILADELPHIA 5, PA.

Teletype Services: Western Union WUX and Bell System PH-72